Make Your Own
FIREWORKS

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BASIC PYROTECHICS SAFETY LAWS

"There are old pyros,
and there are bold pyros,
but there are not very many
old, bold pyros."

1. Never use metal or other hard materials for tubes or casings, use paper and cardboard. What would you rather have flying towards you, confetti or shrapnel?

2. Always know you chemicals; working with certain chemicals requires eye and/or respiratory equipment.

3. Always experiment in an appropriate place, you should have a fire extinguisher handy and should be no where near people or property.

4. Always keep your work area clean. Tools and messes should be cleaned up immediately. Mixing the chemicals because you where to lazy to clean your tools could result in disaster.

5. Never under any circumstances use sparking tools. Iron and steel should be avoided.

6. Treat your pyrotechnic compounds as you would a baby, avoid friction and shock.

7. One chemical should be ground at a time. Never grind potassium chlorate with any other chemical.

8. Avoid using electrical tools and devices when working with pyrotechnics. Sparks do occur.

9. Unless you hate life, never smoke around your pyrotechnics.

10. "Better to have a fuse a foot to long than an inch too short." Is it cheaper to use a small amount of fuse on a device or have a finger or two sewed back on?

11. Beginners should never use black match or quick match, stick with green visco fuse. Also, avoid cheaper kinds of fuse.

12. Storage of compositions and chemicals are very important. Only make enough composition for the device(s) you're going to use within a week. Your tubes and such can be made a head of time for quick loading but do not store live devices very long.

13. Store your chemicals safely. Acids, oxidizers, and chlorates should have their own shelves. Chlorates and acids will detonate on contact.

14. Always make your devices step by step. Once finished with a compound or chemical, seal it before moving to the next.

15. Static electricity is very dangerous. Use antistatic sprays and avoid synthetic or cloth clothing. Mix flash powder compositions only on humid days, dry air can ignite flash powder.

16. Never ever mix water with metal powders. Metals such as magnesium and zinc can ignite on contact with water.

17. Like I said before, know your chemicals. Never mix a chemical with another without knowing the properties of both chemicals. Ignition can occur when the wrong chemicals are mixed.

The abbreviation 'qs', which is sometimes used, stands for 'quantity sufficient'. In these cases the required amount is not very critical, and with some experience it is not hard to guess how much should be used. Additional percentages are given as '+x%', where the x% is a percentage of the total weight of the other chemicals. Sometimes compositions must be stabilized: Magnesium or magnalium must always be treated with potassium dichromate. Iron must always be coated with tung- or linseed oil. To all compositions containing nitrates and aluminum an additional +1% boric acid must be added. Compositions containing both sulfur and chlorates or copper ammonium complex salts in combination with nitrates or chlorates are extremely sensitive and should never be used. Compositions containing aluminum or magnesium in combination with nitrates and chlorates should also never be used.

Measuring & Weighing

To begin with here are two important points:
1. **EVERYTHING is measured by weight, not by volume.**
2. The amounts of chemicals in ALL formulas are in percentage.
Now we'll explain what these 2 points mean:

For example, let's say you have the following formula:
(this isn't an actual formula for anything)

Zinc Dust	**50**
Sulfur	**50**

This simply means this mixture is made from 1/2 Zinc Dust and 1/2 Sulfur Powder
(50% Zinc Dust & 50% Sulfur Powder).

You can mix 50 grams of Zinc & 50 grams of Sulfur, or 50 ounces of Zinc and 50 ounces of Sulfur, 100 grams of Zinc & 100 grams of Sulfur, or even 200 tons of Zinc and 200 tons of Sulfur.
All the measurements are 50% of each chemical, and they will all work.

You CANNOT use 1 Tablespoon of Zinc and 1 Tablespoon of Sulfur, or 1 cup of Zinc and 1 cup of Sulfur. Why? Because these are VOLUME measurements.

The reason is that different chemicals weigh different amounts.
1 Tablespoon of Zinc weighs 68 grams and 1 Tablespoon of Sulfur weighs 12 grams.
In the correct formula above there are equal amounts of Zinc & Sulfur. If you measured by volume, say 1 Tablespoon of each, you would wind up with over five times more Zinc by weight than Sulfur. Your formula wouldn't work.

To make things worse, volume measurements are not constant. A tablespoon of Zinc dust may in fact weigh 68 grams today, but may weigh 50 grams or possibly 75 grams tomorrow. Why... because fine powders compact when they sit around (making a tablespoon of it weigh more than it did before), and "fluff up" when disturbed or shaken (making a tablespoon of it weigh less than it did before).

Only weight measurements can be used in chemistry & pyrotechnics.
ALL formulas are measured by weight, usually in grams.

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(Remember! EVERYTHING is measured by weight, not by volume GET A SCALE.)

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Rocket propellants

Rocket propellant #1 ('Candy Propellant')

Comments: This propellant is often referred to as "candy propellant".
Preparation: It is best prepared by melting the potassium nitrate and sugar together, but this is a dangerous operation and could result in accidental ignition during preparation. Dry mixing is possible and much safer but produces lower quality propellant.

Potassium nitrate	74.5
Sugar	25.5

Rocket propellant #2

Comments: The propellant has a burn rate of 0.0385 inch/sec at 100psi and a burn rate of 0.04 inch/sec at 300psi. Burn temperature is approx. 1800K. and ISP=180.

Ammonium nitrate	85-90%
Electrometric binder (HTPB or other urethane plastic)	?

Rocket propellant #3

Comments: Stinks like ammonia when mixed, and hardens faster than normal epoxy curing time. Suggestions for rocket dimensions: 1" rocket tube, 3" fuel length, Durham's water putty nozzle 3/8" thick, and 5/16" diameter. Core in center of fuel about 3/8" diameter through the length.

Ammonium perchlorate, 200 micron	80
Resin (Epon 815 epoxy & curing agent U)	20
Copper chromite	+1%

Rocket propellant #4

Comments: Mixture is somewhat hygroscopic. Low impulse propellant.

Potassium nitrate..................................63
Sugar...27
Sulfur..10

Rocket propellant #5 (Whistling)

Comments: Loud whistling rockets can be made with this. The author of the text this composition was taken from used it in nozzle-less whistling rockets. The rocket casings were 3/4 inch inner diameter, and 3.25 inch length. The fuel grain ended 1/8" from the rear end of the motor tube.
Preparation: 1. Mix the iron oxide with the potassium benzoate and mill this mixture until a very fine powder is obtained. 2. Melt the petroleum jelly in a beaker on low heat. Turn the hot plate or stove off. Make sure no sources of heat or sparks are present before proceeding with the next steps. 3. While stirring, add 5 parts of toluene to each part of petroleum jelly by weight. Lacquer thinner can be substituted for toluene when pure toluene is not available. Continue stirring until the petroleum jelly has completely dissolved in the solvent used. 4. Add the petroleum jelly to the potassium benzoate/iron oxide mix and stir the mixture until it becomes homogenous. 5. Then, slowly add the potassium perchlorate while stirring continuously with a wooden spoon for several minutes until homogenous. At this point, the mixture usually has a consistency of thick soup and the beaker is warm to the touch. If the mixture seems too dry or thick, extra toluene or lacquer thinner can be added at this stage. 6. Spread the composition out in a layer about 1/2" thick on Kraft paper over newspapers to dry overnight. It is important that the mixture has thoroughly dried before pressing motors. A slightly damp mix can cause some shrinkage of the propellant grain over a period of days or weeks, causing the rocket to explode when ignited. 7. When the composition has dried overnight, carefully run the mixture through a 20 mesh sieve twice and store in a paper container so that trace amounts of solvent can evaporate. After several days, the mix is ready to press.

Potassium perchlorate (fine mesh)................64
Potassium benzoate................................32
Red Iron Oxide, Fe2O3.............................1
Petroleum jelly...................................3

Rocket propellant #6 (KNO3 propellant)

Comments: The burning rate of these rocket fuels depends much less on pressure than that of black powder. This widens the acceptable limits of the ratio nozzle area/fuel surface area.

Potassium nitrate..................................72
Carbon..24
Sulfur..4

Rocket propellant #7 (NaNO3 propellant)

Comments: The burning rate of this rocket fuels depends much less on pressure than that of black powder. This widens the acceptable limits of the ratio nozzle area/fuel surface area.

Sodium nitrate	69
Carbon	27
Sulfur	4

Rocket propellant #7 (Zinc/Sulfur)

Comments: Burns very fast, producing lots of smoke. It is not a very effective propellant due to its low energy density.

Zinc	67.1%
Sulfur	32.9%

Space Shuttle Boosters propellant

Aluminum powder	16
Ammonium perchlorate	69.9
Fe_2O_3 catalyst	0.07
Rubber based binder of polybutadiëne acrylic acidacrylonitrile	12.04
Epoxy curing agent	1.96

ESTES C-class rocket engine propellant

Potassium nitrate	71.79
Sulfur	13.45
Charcoal	13.81
Dextrin	0.95

Blue strobe rocket propellant

Comments: The GE silicone II is noted for having an ammonia-like odor, where the GE silicones smell more like vinegar. The dimensions of the rocket made with this propellant were 1 1/8 inch ID, with a 1/2 inch core.
Preparation: Mix the copper oxide, PVC and silicone first, in a plastic bag. Then mix in the ammonium perchlorate. The stuff is said to be somewhat crumbly, and presses well.

Ammonium perchlorate	63
Silicone II	22
Copper (II) oxide	10
PVC	5

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Fountain, Gerb and Bengal fire Compositions

Fountain #1

Barium nitrate	45
Potassium nitrate	5
Meal powder	5
Aluminum	45

Fountain #2

Meal powder	72
Potassium nitrate	7
Charcoal	7
Dark Aluminum	7
Aluminum (-80/+120)	7

Fountain #3

Preparation: Charcoal, sulfur and potassium nitrate are ball milled and very fine. Iron is medium coarse. After mixing (by diaper method), add an equal weight of course meal powder (about 1Fg to 2Fg equivalent), and mix that in too.

Potassium nitrate	50
Charcoal	10
Sulfur	15
Iron	25

Fountain #4

Comments The metal powder can be aluminum, magnalium or titanium.

Black powder, finely powdered	70
Pine charcoal	4
Metal powder	26

Fountain #5

Potassium nitrate	24
Charcoal	4
Sulfur	4
Iron	10

Fountain #6

Potassium nitrate	2
Charcoal	41
Sulfur	1
Iron	1
Meal Powder	6

Fountain #7

Potassium nitrate	2
Charcoal	4
Iron	2
Meal Powder	4

Fountain #8

Potassium nitrate	8
Sulfur	3
Sb2S3	1
Meal Powder	2

Fountain #9

Sb2S3	8
Aluminum	4
Meal Powder	40

Fountain #10

Sb2S3	9
Dextrin	4
Sodium oxalate	6
Meal Powder	40

Fountain #11

Potassium nitrate	3
Charcoal	1
Sulfur	1
Aluminum	1
Meal powder	2

Blue fountain

Preparation: Granulate the mixture with a small amount of alcohol. Let dry and press into tubes. Very slowly burning mixture. Don't substitute shellac with red gum.

Ammonium perchlorate	7
Stearin	2
Copper (II) oxide	1
Shellac	0.5

Gerb #1

Meal powder	73
Iron (60 mesh)	27

Gerb #2

Preparation: The iron must be treated with linseed or tung oil.

Meal powder	4
Charcoal fines	1
Steel fillings	2

Bengal fire #1

Comments: Improved color, larger sparks and increased scatter radius for sparks.

Zr	2-5
Cast iron shot	18-23
Fe powder	20-25
Al powder	2-5
Corn dextrin binder	3-6
Potato starch binder	0.5-1.5
Barium nitrate	balance

Bengal fire #2

Comments: Increased combustion time

di-Buphtalate	3-5
Fe-powder	20-29
Al-powder	4-7
Polyvinylbutyral binder	11-17
NH4NO3 inhibitor	1-4
Ammonium perchlorate	balance

Green bengal fire #1

Barium nitrate	80
PVC	10
Red Gum	10

Green Bengal fire #2

Barium chlorate	90
Shellac	10

Green Bengal fire #3

Barium chlorate	23
Barium nitrate	59
Potassium chlorate	6
Shellac	10
Stearic acid	1

Green Bengal fire #4

Comments: Burns nice and slowly leaving little residue, but not with a green color.

Barium nitrate	6
Potassium nitrate	3
Sulfur	2

Blue Bengal fire #1

Comments: This is a dangerous mixture since it contains a copper ammonium complex and a chlorate.

Potassium chlorate	6
Copper ammonium sulphate	8
Shellac	1
Willow charcoal	2

Blue Bengal fire #2

Comments: Burns moderately fast with a bluish-white color.

Potassium chlorate	40
Copper sulphate	8
Colophonium	6

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Colored Fire Compositions, Flares and Torches

Most pyrotechnic effects are achieved by combining solid fuels with an oxygen containing compound, usually a metal chlorate or nitrate. The beautiful colors in fireworks displays are the result of burning these fuels, which may be various metallic compounds or the powdered metals themselves. Each metal has its own characteristic color when heated to incandescence. Below is an example of a mixture used to produce a white fountain effect. The potassium perchlorate is an oxidizer which provides the oxygen necessary for combustion. Aluminum is the element which produces the white flame and showers of sparks.

Potassium perchlorate..	4 parts
Aluminum flake..	1 part
Aluminum powder..	1 part
Dextrin..	1 part

The dextrin acts as a binder to hold the mass together. Other materials used as binders are: shellac, red gum, rosin, gum arable, and wheat starch. Gum arabic, wheat starch, and dextrin are dampened with water. If shellac, red gum or rosin is used, the mixture must be dampened with alcohol. The binder will also provide part of the fuel of combustion in a mixture.

The following is a partial list of metals and chemical compounds used to produce various colors and effects when combined with an oxidizer. The list is by no means inclusive, and there are many variables affecting color.

RED: Strontium nitrate, strontium carbonate or strontium chloride.
GREEN: Barium nitrate, barium chlorate.

BLUE: Copper carbonate, copper sulphate, copper chloride, and copper nitrate.

ORANGE: Calcium chloride.

YELLOW: Sodium oxalate, sodium chlorate.

PURPLE: Lithium chloride. Combinations of strontium and copper compounds will also produce a purple color. Example: Strontium nitrate and copper oxide.

WHITE: Aluminum or magnesium in the form of powder, flakes or filings. Antimony in the form of powder, or antimony sulpliide.

GREENISH WHITE: Zinc filings. A dramatic increase in color quality can be had by the addition of small quantities of certain chemicals. Compounds that contain large amounts of chlorine greatly intensify and deepen colors. Some of these are: Polyvinyl chloride, hexachlorobenzene, and hexachloroethane. The color of a flare or star is greatly enhanced by the addition of as little as 10 by weight of hexachloroethane to the formula.

[CAUTION: Hexachloroethane is known to cause cancer. Wear skin and respiratory protection.]

The following is a military flare formula. This is a very brilliant magnesium flare, used for battlefield illumination and signaling. The yellow color is intensified by the addition of hexachlorobenzene.

YELLOW FLARE:

Barium nitrate	17
Strontium nitrate	16
Potassium perchlorate	17
Sodium oxalate	17
Hexachlorobenzene..	12
Magnesium	18
Linseed oil	3

As stated all parts or percentages listed in this e-book are by weight. A small chemical balance is all that's required for weighing chemicals. These are available at science and hobby stores for a few dollars. You might also consider purchasing a handloader's powder scale as these are quick, easy and precise.

Blue fire composition #1

Comments: Dangerous mixture, since it contains both a nitrate and a chlorate with a copper ammonium compound and also a combination of chlorate with sulfur.

Sulfur	15
Potassium sulphate	15

Cupric ammonia sulphate..........................15
Potassium nitrate................................27
Potassium chlorate...............................28

Blue fire composition #2

Copper ammonium chloride.........................5
Potassium perchlorate............................24
Stearin..2
Asphaltum..1

Blue fire composition #3

Comments: Dangerous mixture, since it contains sulfur and a chlorate.

Potassium chlorate...............................7
Copper (II) sulfide................................2
Sulfur...4

Blue fire composition #4

Potassium nitrate................................1
Copper (II) oxide..................................1
Hg2Cl2...1
Charcoal...1

Blue fire composition #5

Potassium nitrate................................12
Sulfur...4
Sb2S3..2

Blue fire composition #6

Comments: Dangerous mixture, since it contains both sulfur and a chlorate.

Potassium nitrate................................7.5
Potassium chlorate...............................14
Potassium sulfate................................7
Sulfur...7

Blue fire composition #7

Comments: Dangerous mixture, since it contains both sulfur and a chlorate.

Potassium chlorate	8
Copper sulfate	5
Shellac powder	3
Sulfur	7
Hg_2Cl_2	4

Red fire composition #1

Comments: Burns at a moderate rate with a nice deep red color.

Strontium nitrate	66
Potassium chlorate	25
Powdered shellac	9

Red fire composition #2

Strontium carbonate	16
Potassium chlorate	72
Powdered shellac	12

Red fire composition #3

Strontium nitrate	4
Potassium chlorate	12
Strontium carbonate	3
Kauri powder	5

Red fire composition #4

Preparation: The vaseline/wood dust mixture is prepared by melting 6 parts vaseline and mixing in 8 parts wood dust.

Potassium perchlorate	9
Strontium nitrate	40
Sulfur	11
Colophonium	1
Sugar	1
Antimony	1/2
Vaseline/Wood dust	20

Red fire composition #5

Comments: Dangerous mixture, since it contains both sulfur and a chlorate.

Potassium chlorate	2
Strontium nitrate	5

Charcoal	1
Sulfur	1

Red fire composition #6

Comments: Dangerous mixture, since it contains both sulfur and a chlorate.

Potassium chlorate	1
Calcium carbonate	11
Strontium nitrate	11
Sulfur	4
Charcoal	1

Red fire composition #7

Potassium chlorate	29
Strontium carbonate	6
Orange shellac powder	5

Red fire composition #8

Strontium nitrate	4
Orange shellac powder	1

Red fire composition #9

Comments: Dangerous mixture, since it contains both sulfur and a chlorate.

Strontium nitrate	4
Potassium chlorate	13
Hg2Cl2	4
Sulfur	2.5
Shellac powder	1
Charcoal	1

Green fire composition #1

Comments: Dangerous mixture, since it contains both sulfur and a chlorate.

Barium nitrate	7
Potassium chlorate	3
Sulfur	2

Green fire composition #2

Comments: Dangerous mixture, since it contains both sulfur and a chlorate.

Barium nitrate	3
Potassium chlorate	8
Sulfur	3

Green fire composition #3

Barium chlorate	9
Orange shellac powder	1

Green fire composition #4

Comments: Burns at a moderate rate with a greenish white flame.

Barium nitrate	3
Potassium chlorate	4
Orange shellac powder	1

Green fire composition #5

Comments: Dangerous mixture, since it contains both sulfur and a chlorate.

Barium nitrate	18
Potassium chlorate	9
Sulfur	4.5
Shellac powder	1.5
Hg2Cl2	3
Charcoal	1.5

White fire composition #1

Potassium nitrate	24
Sulfur	7
Charcoal	1

White fire composition #2

Potassium nitrate	7
Sulfur	2
Powdered antimony	1

White fire composition #3

Potassium perchlorate	7

Barium nitrate	34
Sulfur	7
Powderd Aluminum	10

White fire composition #1

Potassium nitrate	6
Sb2S3	1
Sulfur	1

White fire composition #2

Potassium nitrate	24
Charcoal	1
Sulfur	1

Yellow fire composition #1

Potassium nitrate	4
Sulfur	1
Charcoal	2
Sodium chloride	3

Yellow fire composition #2

Comments: Dangerous mixture, since it contains both sulfur and a chlorate.

Potassium chlorate	5
Sodium oxalate	2
Potassium nitrate	1
Charcoal	2
Sulfur	1

Yellow fire composition #3

Comments: Dangerous mixture, since it contains both sulfur and a chlorate.

Potassium chlorate	9
Sodium oxalate	3
Sulfur	3
Shellac	1.5

Yellow fire composition #4

Comments: Dangerous mixture, since it contains both sulfur and a chlorate.

Potassium chlorate	8
Sulfur	2
Sodium carbonate	3

Purple fire composition

Comments: Dangerous mixture, since it contains both sulfur and a chlorate.

Copper sulfate	1
Potassium chlorate	1
Sulfur	1

Magnesium flare #1

Preparation: Magnesium is corroded by some nitrates when damp. It is common practice to coat the magnesium before use. about 4% linseed oil or some potassium dichromate can be used for that purpose.

Barium nitrate	22.5
PVC	13
Magnesium (grade 0)	35
Potassium perchlorate	22.5
Polyester	5

Magnesium flare #2

Comments: Heat of reaction: 6.134 kJ/g, Gas volume: 74 cm3/g, ignition temperature: 640°C, impact sensitivity test: 19% of TNT

Sodium nitrate	38
Magnesium	50
Laminac	5

Green torch #1

Comments: Note that calomel is a very toxic compound.

Barium chlorate	5
Barium nitrate	4
Shellac	1
Calomel	2

Green torch #2

Barium nitrate	5
potassium perchlorate	6

K.D. Gum	2
Sulfur	3

Green torch #3

Comments: Dangerous mixture, since it contains both an ammonium compound and a chlorate.

Barium nitrate	40
Potassium chlorate	1
K.D. Gum	6
Ammonium chloride	1

Blue torch #1

Comments: Note that calomel and Paris green are both very toxic compounds.

Potassium perchlorate	5
Copper acetoarsenite (Paris Green)	2
Dextrin	1
Calomel	1

Blue torch #2

Comments: This mixture is incompatible with nitrates and chlorates due to the presence of a copper-ammonium compound.
Preparation: 'Sugar of milk' is lactose.

Potassium perchlorate	24
Copper ammonium sulfate	6
Sugar of milk	2
Sulfur	9

Blue torch #3

Comments: This mixture is incompatible with nitrates and chlorates due to the presence of a copper-ammonium compound.

Potassium perchlorate	24
Copper ammonium chloride	6
Stearin	2
Asphaltum	1

Purple torch #1

Comments: Note that calomel is very toxic.

Strontium nitrate	7
Potassium perchlorate	9
Copper (II) oxide	6
Calomel	3
Sulfur	5

Amber torch

Strontium nitrate	36
Sodium oxalate	8
Shellac	5
Sulfur	3
Potassium perchlorate	10

Aluminum torch

potassium perchlorate	13
Fine aluminum powder	6
Flake Aluminum	5
Dextrin or lycopodium	1

Red and aluminum torch #1

Comments: The composition is a modification of the 'Aluminum torch'. Suggested dimensions for the torch are 2.22 cm diameter and 45 cm length.
Preparation: Before ramming, this formula should be moistened with a solution of 1 part shellac in 16 parts alcohol and 1 part of this solution used to every 36 parts of composition. As this mixture is somewhat difficult to ignite it is necessary to scoop out a little from the top of the torch and replace it with a starting fire composition. Meal powder can be used for that purpose.

Strontium nitrate	35
Potassium perchlorate	7
Shellac	4
Coarse flake Aluminum	4
Lycopodium	1

Red and aluminum torch #2

Comments: The composition is a modification of the 'Aluminum torch'. Suggested dimensions for the torch are 2.22cm diameter and 45cm length.
Preparation: Before ramming, this formula should be moistened with a solution of 1 part shellac in 16 parts alcohol and 1 part of this solution used to every 36 parts of composition. As this mixture is somewhat difficult to ignite it is necessary to scoop out a little from the top of the torch and replace it with a starting fire composition. Meal powder can be used for that purpose.

Strontium nitrate	13
Sulfur	3
Mixed Aluminum	3

Extra bright torch

Comments: According to the original text: "A torch of heretofore unheard of brilliance and giving an aluminum illumination, in the 2.54cm size, of what is said to be 100000 candlepower". Testing with paint grade aluminum revealed that it burns very bright indeed at a steady slow burn rate and with little residue. It is easily pressed in tubes.
Preparation: Rub the Vaseline into the barium nitrate. Mix the sulfur and the aluminum separately. Then mix it with the barium nitrate/vaseline mixture. A starting fire mixture is required for ignition. The 'starting fire #1' composition can be used for that purpose.

Barium nitrate	38
Mixed Aluminum	9
Sulfur	2
Vaseline	1

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Sparkler Compositions

Sparkler Chemistry

A sparkler consists of several substances:

- An oxidizer
- A fuel
- Iron, steel, aluminum, or other metal powder
- A combustible binder

In addition to these components, colorants and compounds to moderate the chemical reaction also may be added. Often, firework fuel is charcoal and sulfur. Sparklers simply may use the binder as the fuel. The binder is usually sugar, starch, or shellac. Potassium nitrate or potassium chlorate may be used as oxidizers. Metals are used to create the sparks. Sparkler formulae may be quite simple. For example, a sparkler may consist only of potassium perchlorate, titanium or aluminum, and dextrin.

Reaction Details
Now that you've seen the composition of a sparkler, let's consider how these chemicals react with each other:

Oxidizers
Oxidizers produce oxgen to burn the mixture. Oxidizers are usually nitrates, chlorates, or perchlorates. Nitrates are made up of a metal ion and a nitrate ion. Nitrates give up 1/3 of their oxygen to yield nitrites and oxygen. The resulting equation for potassium nitrate looks like this:

$2\ KNO_3(solid)\ \text{-->}\ 2\ KNO_2(solid) + O_2(gas)$

Chlorates are made up of a metal ion and the chlorate ion. Chlorates give up all of their oxygen, causing a more spectacular reaction. However, this also means they are explosive. An example of potassium chlorate yielding its oxygen would look like this:

2 $KClO_3$(solid) --> 2 KCl(solid) + 3 O2(gas)

Perchlorates have more oxygen in them, but are less likely to explode as a result of impact than are chlorates. Potassium perchlorate yields its oxygen in this reaction:

$KClO_4$(solid) --> KCl(solid) + 2 O_2(gas)

Reducing Agents
The reducing agents is the fuel used to burn the oxygen produced by the oxidizers. This combustion produces hot gas. Examples of reducing agents are sulfur and charcoal, which react with the oxygen to form sulfur dioxide (SO_2) and carbon dioxide (CO_2), respectively.

Regulators
Two reducing agents may be combined to accelerate or slow the reaction. Also, metals affect the speed of the reaction. Finer metal powders react more quickly than coarse powders or flakes. Other substances, such as cornmeal, also may be added to regulate the reaction.

Binders
Binders hold the mixture together. For a sparkler, common binders are dextrin (a sugar) dampened by water, or a shellac compound dampened by alcohol. The binder can serve as a reducing agent and as a reaction moderator.

How Does it Work?

Let's put it all together: A sparkler consists of a chemical mixture that is molded onto a rigid stick or wire. These chemicals often are mixed with water to form a slurry that can be coated on a wire (by dipping) or poured into a tube. Once the mixture dries, you have a sparkler. Aluminum, iron, steel, zinc or magnesium dust or flakes may be used to create the bright, shimmering sparks. The metal flakes heat up until they are incandescent and shine brightly or, at a high enough temperature, actually burn. A variety of chemicals can be added to create colors. The fuel and oxidizer are proportioned, along with the other chemicals, so that the sparkler burns slowly rather than exploding like a firecracker. Once one end of the sparkler is ignited, it burns progressively to the other end. In theory, the end of the stick or wire is suitable to support it while burning.

Important Reminders

Obviously, sparks cascading off of a burning stick present a fire and burn hazard. Less obviously, sparklers contain one or more metals to create the sparks and any colors, so they can present a health hazard. For example, they should not be burned on cakes as candles or otherwise used in a manner which could lead to consumption of the ash. So use sparklers safely and have fun!

Sparkler #1

Potassium perchlorate............................40

Mixed titanium fines	40
Dextrin	18
Propyl guar	2

Sparkler #2

Potassium nitrate	14
Sulfur	3
Charcoal	3
Aluminum	2
Binder	qs

Sparkler #3

Comments: Better visual effect, better spark lifting altitude. lower combustion rate and better safety.

Charcoal	5-20
Nitroguanidine	10-20
Ti or Mg/Al alloy powder (as spark forming component)	10-20
Fe-powder (spark forming)	10-30
Potassium nitrate	balance

Sparkler #4

Potassium perchlorate	60
Aluminum	30
Dextrin	10

Sparkler #5

Preparation: Dextrin binder can probably be used.

Potassium nitrate	14
Sulfur	3
Charcoal	3
Aluminum	2

Sparkler #6

Barium chlorate	16
Aluminum flitter	24
Shellac	3

Sparkler #7

Strontium nitrate	5
Shellac	1

Sparkler #8

Potassium perchlorate	50
Fine Aluminum	35
Dextrin	15

Sparkler #9

Potassium nitrate	7
Sulfur	2
Charcoal	4
Aluminum	3

Sparkler #10

Comments: The composition burns very fast and explosively if one doesn't pay extreme attention towards the diameter of the sparkler. It is found that if the comp is thinner than 1.8 mm then the propagation stops. If the diameter is more than 2.0 mm the burning is too fast, sending sparks all the way down to the ground. Another severe problem is keeping the ingredients mixed in the suspension. The Ti has a very strong tendency of ending up in the bottom of the test tube, making a plug. Another problem is that after the first dipping and subsequent drying, the second (and last) dipping has to be performed very, very fast or else the first dipping is spoiled, hence the bound dextrin is redisolved. Using coarser perchlorate, finer titanium and making the dipping mixture thicker (by using less solvent) may solve these problems.

potassium perchlorate	47
Titanium	47
Dextrin	6

Sparkler #11

Preparation: The aluminum is probably supposed to be atomized, but experimentation is required.

Potassium nitrate	14
Sulfur	3
Charcoal	3
Aluminum	2
Binder	qs

Sparkler #12

Preparation: Guar gum comes from the seeds of the legume Cyanopsis Psoralioides. It should be possible to substitute red gum.

Potassium perchlorate	40
Mixed titanium fines	40
Dextrin	18
Propyl guar	2

Sparkler #13

Preparation: Mix the composition with a 10% dextrin solution in water, and dip iron wire or wood in the moist composition. Adding 500 parts strontium nitrate will produce a red color; adding 60 parts barium nitrate will produce a green color.

Potassium chlorate	300
Aluminum granules	60
Charcoal	2

Sparkler #14

Potassium perchlorate	10
Aluminum, finely powdered	7
Dextrin	3
Water	20

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Smoke Compositions

White smoke

Potassium nitrate	4
Charcoal	5
Sulfur	10
Wood dust	3

Red smoke

Potassium chlorate	15
para-nitroaniline red	65
Lactose	20

Green smoke

Synthetic indigo	26
Auramine (yellow)	15
Potassium chlorate	35
Lactose	26

Smoke composition #1

Comments: Different sources mention different compositions. The most often mentioned one is given here.
Preparation: The mixture is most successful when prepared by melting the sugar and potassium nitrate together on low heat, but this requires good stirring, and there is a risk of accidental ignition. The molten mixture can be poured in cardboard containers and a fuse inserted while the mixture solidifies. Another idea is to insert "Strike Anywhere" wooden matches to use as the fuse.

Potassium nitrate	50
Sugar	50

Or

Potassium nitrate.................................60
Sugar..40

Smoke composition #2

(Composition is an U.S. military smoke composition)
Comments: The mixture is difficult to ignite. Hexachloroethane is poisonous, and can be replaced by 72 parts PVC. This, however, makes the mixture yet harder to ignite. The zinc oxide can be replaced by titanium dioxide (2 parts ZnO replaced by 1 part TiO_2). The smoke is slightly irritating and not suitable for indoor use.

Zinc oxide.......................................45
Hexachloroethane.................................45
Aluminum...10

Smoke composition #3

Zinc powder......................................35
CCl_4...41
Zinc oxide.......................................20
Diatomeous earth.................................5

Smoke composition #4

Zinc powder......................................25
CCl_4...50
Zinc oxide.......................................20
Diatomeous earth.................................5

Smoke composition #5

Comments: Heat of reaction: 2.579 kJ/g, Gas volume: 62 cm^3/g, ignition temperature: 475°C, impact sensitivity test: 15% of TNT

Zinc...69
Potassium perchlorate............................19
Hexachlorobenzene................................12

6

Flash, Burst Charges and Whistle Mix

Black Powder Coated Rice Hulls

BP coated rice hulls are commonly used as a burst charge in aerial shells. Many people have trouble finding commercial-quality fine black powder (commonly called "meal" or Meal-D) to use for coating rice hulls for shell burst. Homemade black powder made by simply screening the ingredients together several times will work fine, though it is not very powerful and may need a little flash or whistle mix added to it for extra oomph.

Here's a rice hull tip that was in American Fireworks News a while back (fromTom Perigrin, I believe).

When making your [coated] rice hulls, divide the meal up into 5 increments. Add 5% dextrin to the first four increments.

Now soak and drain your hulls as usual [for an hour in warm water]. Add the first increment of meal and shake, rattle, and roll as usual. Add the next increment, shake, rattle, roll. Repeat until there are four increments of powder on the hulls.

Now for the secret to really nice hulls: do not add dextrin to the last increment of meal! The dextrin makes the meal sticky so it sticks to the hulls and to the next layer of meal. On the last layer the hulls are already coated with sticky meal so the dextrin-less meal will stick just fine, BUT since the sticky hulls are coated with non-sticky meal they won't stick together into lumps! Really shake the hulls good on the last increment to break up the lumps and coat 'em with dextrin-less meal.

Flash #1

Comments: The sulfur can be replaced by antimony trisulfide and the sound of a salute made with this composition will change very little.

potassium perchlorate	50
Aluminum	23
sulfur	27

Flash #2

potassium perchlorate	70
Aluminum (dark pyro)	30

Flash #3

Comments: Larger percentage of aluminum results in a stronger flash. This composition is slightly less sensitive than the usual perchlorate mixtures which also contain sulfur.

Potassium perchlorate	65...70%
Aluminum powder	rest (up to 100%)

Flash #4

Potassium perchlorate	3
Aluminum, 400 mesh	3
Sulfur	1

Flash #5

Comments: This is a relatively safe flash composition. Burns with a brilliant white light in an open tube, or when unconfined. When well confined, it produces a loud, low pitched report and a short but intense flash.

Potassium nitrate	50
Sulfur	30
Aluminum	20

Flash #6

Comments: Can be ignited by a fairly low temperature flame, and produces a greenish flash when magnesium is used. Burns very fast, and produces a loud report even in an open container.

Magnesium or Aluminum	1
Barium sulfate	1

Flash #7

Comments: Relatively insensitive.

Barium nitrate	4
Alumium (fine mesh)	2
sulfur	1

Flash #8

Preparation: Dampen the mix lightly with water and mix thoroughly such that the material is crumbly but then packs tightly into a ball. If it is at all greasy feeling or mushy, there is way too much water. Save some dry mix on the side just in case it becomes too wet during the dampening. Granulate the damp comp by rubbing the packed ball over a 20 mesh screen. Do not use any screens larger than 20 mesh. If the screen plugs, the comp is too damp. Add drier comp and thoroughly mix in. After drying the granulated powder, it can be used in flash bags. About 3 to 5 grams works well in a 3 inch shell. Experimentation is needed to adjust the amount of burst for good results with different stars and shell construction. This powder can also be used ungranulated, in a central flash bag, in larger shells.

Potassium nitrate	3
Potassium perchlorate	3
Dark aluminum (USB 809)	3
Barium nitrate	1
Antimony sulfide (CN)	1
Sulfur	1
Dextrin	1/2

Flash #9

Comments: The use of permanganate in pyrotechnic compositions is not recommended, since it is unstable and will decompose over time. Also, like all flash mixtures, this mixture is quite sensitive and powerful. Great care should be taken when handling this mixture.

Potassium permanganate	12
Aluminum	7
Sulfur	10

Flash #10

Comments: Listed as a report formulation.

Potassium perchlorate	80
Aluminum	27
Sulfur	3

Flash #11

Comments: Listed as a report formulation. Shimizu states that this composition produces the loudest report obtainable with a potassium perchlorate/aluminum/sulfur composition.

Potassium perchlorate	64
Aluminum	23
Sulfur	13

Flash #12

Comments: Listed as a report formulation. This composition produces slightly less noise than "Flash #11", but is safer to handle than similar compositions containing sulfur.

Potassium perchlorate	72
Aluminum	28

Flash #13

Comments: Listed as a report formulation

Barium nitrate	68
aluminum, dark pyro	23
Sulfur	9

H3 Bursting charge

Comments: This energetic burst charge is used for small diameter shells (2...3 inch), since it makes a large and symmetrical burst possible. Besides the composition below, a ratio of chlorate to hemp coal of 10:3 is also popular. The sensitivity of this mixture to shock and friction is unexpectedly low, as long as the composition does not come into contact with sulfur or sulfur compounds.

Potassium chlorate	75
Hemp coal (or Paulownia coal)	25
Glutinous rice starch	+2%

Potassium perchlorate bursting charge #1

Comments: This energetic burst charge can be used for small shells, but is unsuitable for the smallest diameters (2...3 inch). It is much safer to handle than the H3 bursting charge since it contains no chlorates.

Potassium perchlorate	70
Hemp coal (or Paulownia coal)	18
Sulfur	12
Glutinous rice starch	+2%

Potassium perchlorate bursting charge #2

Comments: Shimizu lists this composition as 'burst charge No. 5'. This compositions sensitivity is quite low, although higher than that of black powder. The explosive force of this composition is lower than that of the 'Potassium perchlorate bursting charge #1'. This burst charge is often used in shells of middle and large diameter (6...10 inch).

Potassium perchlorate	70
Hemp coal (or Paulownia coal)	30
Glutinous rice starch	+2%

Potassium perchlorate bursting charge #3

Comments: Shimizu lists this composition as 'burst charge No. 44'. The potassium bichromate catalyses the decomposition of the potassium perchlorate. This composition's sensitivity is quite low, although higher than that of black powder. The explosive force of this composition is lower than that of the 'Potassium perchlorate bursting charge #1'. This burst charge is often used in shells of middle and large diameter (6...10 inch).

Potassium perchlorate	70
Hemp coal (or Paulownia coal)	30
Potassium bichromate	5
Glutinous rice starch	+2%

Potassium perchlorate bursting charge #4

Comments: Shimizu lists this composition as 'burst charge No. 46'. The potassium bichromate catalyses the decomposition of the potassium perchlorate. This composition's sensitivity is quite low, although higher than that of black powder. The explosive force of this composition is higher than that of the 'Potassium perchlorate bursting charge #1', especially when the particle size of the carbon is small.

Potassium perchlorate	70
Hemp coal (or Paulownia coal)	30
Lampblack	25
Potassium bichromate	+5%
Glutinous rice starch	+2%

Smokeless flash powder

Zirconium	28
Zirconium hydride	7
Magnesium	7
Barium nitrate	30
Barium oxyde	25
Rice starch	5

Photoflash

Comments: Heat of reaction: 8.989 kJ/g, Gas volume: 15 cm3/g, ignition temperature: 700°C, impact sensitivity test: 26% of TNT. half a pound of this flash delivers 120 million candlepower. It is used in the M120A1 and M112A1 flare cartridges.

Aluminum (20 micron; atomized)...................40
Potassium perchlorate (24 micron)................30
Barium nitrate (150 micron)......................30

Purple Flash

Magnesium..10
Potassium perchlorate............................10
Cupric oxide....................................3
Strontium nitrate................................3
PVC..1

Yellow flash

Magnesium..1
Sodium nitrate...................................6

Green flash

potassium perchlorate............................6
barium nitrate...................................3
Aluminum powder..................................5

Whistle mix #1

Potassium perchlorate............................72.5
Sodium salicylate................................27.5

Whistle mix #2

Potassium nitrate................................30
Potassium dinotrophenate.........................70

Whistle mix #3

Potassium perchlorate............................70
Sodium benzoate..................................30

Whistle mix #4

Potassium chlorate................................40
Sodium chlorate..................................10
Potassium nitrate.................................30
Sodium salicylate.................................10
Paraffin oil.....................................10
Ferric oxide.....................................+0.2

Whistle mix #5

Comments: This mixture is quite sensitive to friction and shock.

Potassium chlorate................................75
Gallic acid......................................25

7

Miscellaneous Compositions

Black powder

Source: Various sources
Comments: Two methods of preparation exist, the precipitation or CIA method, and the ball milling method. The latter produces slightly superior results. Special attention should be given to the charcoal used. Charcoal is best obtained by pyrolysis of soft-wood. Preferred types of wood are willow, grapevine and laurel. In general all young, thin soft-woods without hard knots can be used. Although several different compositions are used for several purposes, the composition given here is used most often:
Preparation: Merely mixing the charcoal, sulfur and potassium nitrate by hand does not make black powder. They must really be incorporated into each other. This can be done by ball milling or by the salting out ('CIA') method. A detailed description of the process can be found in many books.

Potassium nitrate	75
Charcoal	15
Sulfur	10

Yellow powder

Comments: It is sometimes called "Fulminating powder". The mixture burns three times quicker than common black powder.
Preparation: The compounds are sometimes molten together, which appears to be a very dangerous operation.

Potassium nitrate	3
Potassium carbonate	2
Sulfur	1

Priming composition #1

Barium nitrate	4
Potassium nitrate	3
Sulfur	1
Shellac	1

Priming composition #2

Potassium permanganate	54
Powdered iron	47

Priming composition #3

Comments: Suitable for priming most stars. Chlorate stars or stars containing ammonium compounds should never be primed with this composition. It can be stored in small plastic containers.

Potassium nitrate, fine, sieved	75
Sulfur, fine (preferably flour)	10
Charcoal, fine, sieved	15

Priming composition #4

Comments: Suitable for priming stars. Aluminum and manganese dioxide aid in ignition, but are not necessary.

Potassium perchlorate	80
Charcoal, fine	15
Red gum	4
Manganese dioxide (optional)	9
Aluminum, (fine flake or pyro grade; optional)	4
Dextrin	2

Priming composition #5

Comments: This type of prime helps reduce the friction and impact sensitivity of chlorate stars which is especially important when shells fire from the mortar and experience set-back or "kick" from lift acceleration.

Potassium perchlorate	68
Charcoal, air float	20
Silicon or Aluminum	9
Dextrin	3

Priming composition #6

Comments: This prime is safe to use with chlorate stars and gives a much better color than a black powder prime. The difference is most noticeable on red stars which tend to a dark salmon color when primed with black powder.
Preparation: Dissolve the potassium nitrate in hot water and mix with the charcoal.

Potassium chlorate................................52
Potassium nitrate.................................8
Charcoal..30
Lampblack...10
Binder..+5%

Priming composition #7

Comments: Standard black powder priming cannot be used with stars that contain ammonium perchlorate, since a double decomposition reaction forms the highly hygroscopic ammonium nitrate. This makes the stars unignitable. Replacing the potassium nitrate prime by this priming composition solves that problem.

Sodium nitrate....................................80
Paulownia coal....................................15
Sulfur..5

Priming composition #8

Comments: Used for strobe stars of ammonium perchlorate base to prevent nitrates from the outer priming to react with the ammonium perchlorate. The layer should be at least 1-2mm thick.

Potassium perchlorate.............................74
Rosin (BL combustion agent) or Red gum............12
Hemp coal (or paulownia coal).....................6
Aluminum (fine flake).............................3
Potassium bichromate..............................5

Delay composition #1

Comments: Heat of reaction: 2.010 kJ/g; Gas volume: 13 cm3/g; Ignition temperature: 450°C; impact sensitivity test: 12 % of TNT.

Barium chromate...................................90
Boron...10

Delay composition #2

Comments: Heat of reaction: 2.081 kJ/g; Gas volume: 12 cm3/g; Ignition temperature: 485°C; impact sensitivity test: 23 % of TNT.

Barium chromate...................................60
Zirconium-nickel alloy............................26
Potassium perchlorate.............................14

Changing Relay #1

Comments: This type of composition is put between two color layers in a star to create the illusion that all the stars change their color clearly and simultaneously in spite of slight deviations in manufacture.

Potassium perchlorate	35
Potassium nitrate	35
Hemp coal (or Paulownia coal)	24
Soluble glutinous rice starch	6

Changing Relay #2

Comments: This type of composition is put between two color layers in a star to create the illusion that all the stars change their color clearly and simultaneously in spite of slight deviations in manufacture.

Potassium perchlorate	81
Red gum	13
Soluble glutinous rice starch	6

Golden rain #1

Comments: Burns with a yellow color, and emits yellow sparks that are formed by the slowly burning lampblack.

Potassium nitrate	18
Sulfur	8
Lampblack	5

Golden rain #2

Comments: A burn with a yellow color, and emits yellow sparks that are formed by the slowly burning lampblack and the iron filings.

Potassium nitrate	10
Sulfur	2
Lampblack	2
Fine iron filings	7

Fire dust

Comments: The composition spreads a large amount of long lived orange fire dust particles. The lifetime of those particles depends mainly on the consistency and type of charcoal.
Preparation: The components must be intimately mixed. This can be done by dissolving the potassium nitrate in a minimum amount of boiling water, adding the charcoal and sulfur and

precipitating the potassium nitrate in the form of fine particles by adding a large amount of isopropyl alcohol and cooling the solution as fast as possible to 0°C, followed by filtering and drying.

Potassium nitrate	58
Charcoal	35
Sulfur	7

Senko Hanabi (Japanese sparklers), sulfur based

Comments: For more details on what the effect looks like and how devices can be constructed, look at §10.4, "The phenomenon of Senko-Hanabi" in Shimizu's book (on page 68). Realgar may be used instead of sulfur, see 'Senko Hanabi (Japanese sparklers), realgar based' for a realgar based formula. The realgar based formula produces larger en more beautiful sparks.

Potassium nitrate	60
Charcoal or soot	10-20
Sulfur	20-30

Senko Hanabi (Japanese sparklers), realgar based

Comments: Sulfur may be used instead of realgar, see 'Senko Hanabi (Japanese sparklers), sulfur based' for a sulfur based formula. This realgar based formula produces larger en more beautiful sparks than the sulfur based formula.

Potassium nitrate	35
Charcoal or soot	20
Realgar	45

"Pharaoh Snakes"

Comments: When lighted, this composition produces very voluminous snake-shaped ash. Mercury compounds are very poisonous, and extreme caution should be exercised during preparing and handling this composition. Wear gloves at all times, and use a fume hood.
Preparation: Instructions for making mercuric thiocyanate: 1) Dissolve 64 parts of mercuric nitrate in water, and separately dissolve 36 parts potassium thiocyanate in water. 2) Mix both solutions, and filtrate to collect the precipitate that forms upon mixing. 3) Rinse the collected precipitate 3 times with distilled water, and place it in a warm (not hot) place to dry.

Mercuric thiocyanate	100
Dragant	5
arabic gum binder	qs

"Simple Snakes"

Preparation: Mix together Potassium nitrate, Potassium dichromate and Powered sugar adding just enough Mucilage of acacia so the powders hold their shape when molded into a small pellet. Set aside to dry.

Potassium nitrate	1
Potassium dichromate	2
Powered sugar	1
Mucilage of acacia	Binder

Thermite

Comments: This composition produces an enormous amount of heat (83.7 kJ per mol of iron oxide that has reacted), molten iron and aluminum oxide. Other metal oxides can be substituted to make other thermite-like compositions that behave differently. Some may explode (like CuO with aluminum or PbO_2 with aluminum), so caution is required when experimenting with different mixtures.

Red iron oxide, Fe_2O_3	3
Aluminum	1

Red thermit

Comments: This mixture is sometimes used for priming.

Pb_3O_4	80
Ferro-silicon	20

Electric Match

Comments: This composition does not require the use of a bridge wire. The composition itself acts as a resistor. Comments from the poster: "The matches fire just fine on 200 feet of #16 gauge wire and a standard 12V battery two at a time. Sometimes there's a delay...I haven't tested these on the high power electric firing systems so I don't know how they fare."
Preparation: 1) Bind in water. Make CMC & Water into a mostly soupy mess. Add components into a container and mix well. 2) Dip freshly stripped wire with both conductors about 1mm or slightly less between them, evenly parallel. The longer the exposed metal on the wire, the less Ohmage the match will have. Allow to dry in vertical hanging position. Redip as necessary. I find that two dips are just fine. 3) Once the comp is dry, you will need to coat it with NC (Nitrocellulose) lacquer. I find that two dips in the NC lacquer is enough to keep the very brittle comp from cracking or splitting while maneuvering the wire into your shell or mine or rocket motor. I normally will color the double-dippers with some Iron Oxide stirred into the NC Lacquer so I have a visual that they're unsuitable for firing whistle motors. (Double Dipped tend to go BANG, and destroy the motor).

Potassium chlorate, Ball milled into a fine powder	16
Conductive lampblack	3
Magnalium (50/50), 200 mesh	3

Atomized aluminum, 120 mesh.......................2
Zirconium, 200 mesh (optional)...................2
CMC Binder (carboxymethylcellulose)..............5

Veline's priming

Source: This set of compositions was invented by Robert Veline and is used in Kosankie's 'Chemistry of Fireworks (Chemistry of color) class'.
Comments: These compositions are part of a matched set invented by Robert Veline. The compositions mix compatibly to produce a wide range of other colors. Examples are given below. The wood meal in this prime makes the stars a little 'fuzzy', making the stars much easier to ignite. Without the wood meal prime the stars are often blown blind.
Preparation: Summary of Robert Veline's own comments: "Potassium perchlorate is a fine powder. Parlon is Hercules brand or Superchlon brand from Ishihara co. ltd. Red gum is a fine powder. Copper (II) oxide may be substituted by copper carbonate without much change in performance. Calcium carbonate is 200 mesh, 'Whiting'. More pure forms slow the burn rate and degrade the color."

Potassium perchlorate............................55
Charcoal, air float..............................20
Wood meal, 70 mesh...............................6
Red Iron Oxide, Fe2O3............................5
Magnalium (50/50)................................5
Potassium dichromate.............................5
Dextrin..4

Brilliant core coating composition

Comments: This composition can be used to prime the 'Brilliant Core' stars (see effect stars). roll the cores in this prime until they are round.

Potassium perchlorate............................33
Barium nitrate...................................34
Aluminum (fine flake)............................10
Rosin (BL combustion agent).......................8
Antimony trisulfude (or sulfur)..................9
Boric acid.......................................1
Soluble glutinous rice starch....................5

Iron Sand

Used to give coruscations in fire-works, is far better than iron or steel-filings. It is made by beating cast steel or iron into small pieces on an anvil. These are sifted into 4 sizes, the smallest for the smallest pieces; and vice versa. The coruscations produced by these are exceedingly brilliant. The sand should be kept in a dry place in a well closed bottle as any rust damages it. Fireworks containing it should not be made very long before using.

8

Colored Stars

Red star #1

Comments: The perchlorate can be substituted by chlorate without changing the color.

Potassium perchlorate	66
Red gum	13
Lampblack	2
Strontium carbonate	12
Polyvinyl chloride	2
Soluble Glutinous Rice Starch	5

Red star #2

Preparation: Dissolve shellac in boiling ethanol, add the other ingredients and proceed as usual. The stars take unexpectedly long to dry. They can be dried in the sun or in a vacuum. Smaller stars dry faster.

Potassium chlorate	20
Strontium nitrate	60
Shellac	20

Red star #3

Preparation: Dissolve shellac in boiling ethanol, and add the other ingredients.

Potassium chlorate	65
Strontium carbonate	15
Shellac	20

Red star #4

Preparation: Dissolve shellac in boiling ethanol, and add the other ingredients.

Potassium perchlorate	44
Strontium nitrate	31
Red gum	15
Shellac (binder)	5
PVC or saran	8 or 7

Red star #5

Preparation: Add water. For priming "priming composition #7" from the chapter with miscellaneous compositions can be used.

Ammonium perchlorate	30
Potassium perchlorate	35
Strontium carbonate	18
Hexamine	2
Charcoal, fine	2
Red gum	16
Dextrin	4

Red star #6

Comments: Dangerous mixture, since it contains both sulfur and a chlorate.
Preparation: Bind with shellac dissolved in ethanol.

Potassium chlorate	9
Sulfur	2
Lampblack	1
Strontium nitrate	9

Red star #7

Potassium nitrate	36
Sulfur	30
Meal powder	36
Strontium nitrate	40
Antimony sulfide	5
Charcoal	12

Red star #8

Comments: Produce as a cut star

Potassium perchlorate	70
Strontium carbonate	15
Red gum	9

Charcoal 150 Mesh................................2
Dextrin..4

Red star #9

Comments: Produce as a pressed star

Strontium nitrate................................55
Magnesium..28
PVC..17

Red star #10

Comments: Crackling stars can be made with this composition. The poster used large pistol primers (idea from Best of AFN II), coated with 70%KClO4/30% Dark aluminum for cores, and rolled these into stars with the star mixture. The stars were hard to ignite and needed priming.

Potassium perchlorate............................68
Strontium carbonate..............................13
Red gum..14
Dextrin..5

Red star #11

Preparation: The magnesium must be coated with linseed oil. Use an acetone or alcohol solvable binder.

Potassium perchlorate............................30
Strontium nitrate (anhydride)....................20
Magnesium, 60 mesh...............................30
PVC..18
Lampblack or Paulownia coal......................2

Red star #12

Ammonium perchlorate.............................41
Magnesium, 60 mesh...............................33.3
Red gum..9.5
Strontium carbonate..............................9.5
Potassium bichromate.............................1.9
Soluble glutinous rice starch....................4.8

Red star #13

Preparation : Dampen with 35% alcohol

Potassium chlorate	48
Red gum or shellac	6
Fine Charcoal	8
Strontium carbonate	8
Dextrin	3

Red star #14

Preparation: Dampen with 35% alcohol

Potassium perchlorate	67
Strontium carbonate	14
Powdered rosin	13
Wheat starch	6

Green star #1

Barium nitrate	28.3
Potassium Perchlorate	47.2
Parlon	4.7
Red Gum	14.2
Soluble Glutinous Rice Starch	5.6

Green star #2

Comments: A simple but nice (somewhat yellowish) green.
Preparation: Dissolve shellac in boiling ethanol.

barium nitrate	7
potassium chlorate	7
shellac	2

Green star #3

Comments: The composition leaves lots of ash. Ammonium perchlorate improves it (- Green star #4).
Preparation: Mix Parlon with magnesium. Add 50 volume parts of acetone mix well and mix in the other ingredients. If PVC is used, add the correct amount of the solution in THF to the other ingredients.

barium nitrate	50
lab grade magnesium powder	32
Parlon or PVC	18

Green star #4

Preparation: Mix Parlon with magnesium. Add 60 volume parts of acetone for Parlon, mix well and mix in the other ingredients. If PVC is used, add the correct amount of the solution in THF to the other ingredients.

barium nitrate	56
lab grade magnesium powder	32
Parlon or PVC	17
ammonium perchlorate	25

Green star #5

Comments: This mixture can be improved using ammonium perchlorate (Green star #6).
Preparation: Add acetone. Prime with black powder. Aluminum should be very fine, preferably dark pyro grade.

Barium nitrate	65
Aluminum (very fine)	10
Parlon rubber	20
Sulfur	4
Boric acid	2

Green star #6

Comments: Fierce burning.
Preparation: Add acetone. Prime with "Priming composition #7".

Barium nitrate	65
Saran	20
Red gum	3
Sulfur	7
Aluminum (very fine)	10
Ammonium perchlorate	15
Boric acid	2
Dextrin	2

Green star #7

Comments: Beautiful green. Direct substitution of barium nitrate with strontium nitrate produces a nice red.
Preparation: Dissolve shellac in boiling ethanol. Prime with potassium perchlorate based strobe prime

ammonium perchlorate	50
barium nitrate	35
shellac	15

Green star #8

Preparation: Bind with alcohol.

Barium chlorate	8
Lampblack	1
Shellac powder	1

Green star #9

Preparation: Bind with alcohol.

Barium nitrate	3
Potassium chlorate	4
Shellac powder	1
Dextrin	1/4

Green star #10

Potassium nitrate	35
Sulfur	10
Mealpowder	40
Barium nitrate	50
Charcoal	10

Green star #11

Potassium perchlorate	6
Barium perchlorate	12
Aluminum	8
Dextrin	2
Shellac	1

Green star #12

Potassium perchlorate	48
Barium nitrate	32
Red Gum	14
Charcoal	2
Parlon	12
Dextrin	6
Sulfur	5

Green star #13

Potassium perchlorate	28
Barium nitrate	16
Red Gum	4
Charcoal	1
Parlon	10
Dextrin	3
Aluminum #809	5

Green star #14

Barium nitrate	65
Parlon	20
Pyro Aluminum	10
Red gum or sulfur	5
Boric acid	+2

Green star #15

Comments: Original name: 'Emerald green'. The mix is not very sensitive although chlorates are present.
Preparation: Dampen with 75/25 water/alcohol and cut or roll into 10mm stars. The red gum can be replaced with shellac. If shellac is used, dampen with 50/50 water alcohol.

Potassium perchlorate	22
Barium chlorate	43
Barium nitrate	9
Red gum	22
Dextrin	4

Green star #16

Preparation: The magnesium must be coated with linseed oil. Use an acetone or alcohol solvable binder.

Potassium perchlorate	16
Barium nitrate	42
Magnesium, 60 mesh	25
PVC	15
Lampblack or Paulownia coal	2

Green star #17

Preparation: The magnesium must be coated with potassium dichromate.

Ammonium perchlorate	41
Magnesium, 60 mesh	33.3
Red gum	9.5
Barium carbonate	9.5
Potassium bichromate	1.9
Soluble glutinous rice starch	4.8

Green star #18

Preparation : Dampen with 35% alcohol

Barium chlorate	9
Shellac	1

Green star #19

Barium nitrate	65
Potassium perchlorate	15
Aluminum	10
Parlon	16
Boric acid	2
Charcoal	2
Red gum	5
Dextrin	5

Green star #19

Preparation: Dampen with 35% alcohol

Potassium perchlorate	63
Barium nitrate	20
Shellac	15
Powered rosin	2

Blue star #1

Comments: These stars burn much faster and bluer than any mix containing copper.
Preparation: Dampen with alcohol/water 70/30 to make cut or pumped stars.

Potassium perchlorate	66.5
Red gum	9.9
Cupric oxide	13.4
Parlon	5.4
Soluble Glutinous Rice Starch or Dextrin	5.6 or 4.8

Blue star #2

Preparation: Add 25 volume parts of water to dextrin and mix in the other ingredients. Use more water if necessary.

Ammonium perchlorate	60
Sulfur	17
Copper (II) oxide	20
Dextrin (binder)	3
Red gum or Shellac	6

Blue star #3

Preparation: Mix red gum or shellac powder with Parlon. Add 50 volume parts of acetone mix well and mix in the other ingredients.

Potassium perchlorate	63
copper (II) oxide	13
Red gum or Shellac (powdered)	10
Parlon or PVC	14

Blue star #4

potassium perchlorate	65
cuprous chloride (CuCl)	16
sulfur	10
Red gum	7
Parlon or PVC	11 or 12

Blue star #5

Preparation: Add the PVC solution to the other ingredients. Allow some THF to evaporate, form a cake 1 cm thick and allow it to dry on a plastic plate (check that it doesn't dissolve in THF!). Remove the dry cake and cut it into stars with a pair of scissors.

Ammonium perchlorate	63
Copper(II)oxide	13
Sulfur	10
Dextrin	10
PVC	12

Blue star #6

Comments: Dangerous mixture since it contains both sulfur and a chlorate.
Preparation: Bind with dextrin in water.

Potassium chlorate	9
Copper Acetonarsenite	2
Mercurous chloride	1
Sulfur	2

Blue star #7

Comments: This one is inferior to "Blue star 6". Dangerous mixture since it contains both sulfur and a chlorate.
Preparation: Bind with dextrin in water.

Potassium chlorate	12
Copper sulfate	6
Lead chloride	1
Sulfur	4

Blue star #8

Potassium nitrate	40
Sulfur	12
Mealpowder	40
Copper-ammonium nitrate	30
Charcoal	10
Rosin	5

Blue star #9

Potassium perchlorate	60.8
Red Gum	9.0
Basic copper carbonate	12.3
Parlon	13.1
Soluble glutinous rice starch	4.8

Blue star #10

Comments: Crackling stars can be made with this composition. The poster used large pistol primers (idea from Best of AFN II), coated with 70%KClO4/30% Dark aluminum for cores, and rolled these into stars with the star mixture. The stars were hard to ignite and needed priming. The color is a bit pale blue.

Potassium perchlorate	61
Copper carbonate	12
Parlon	13
Red gum	9
Dextrin	5

Blue star #11

Comments: This composition seems just a slight modification of "Blue star #1".

Potassium perchlorate	67.3
Red gum	10.0
Copper oxide	13.6
Parlon	9.1
Rice starch	4.5

Blue star #12

Ammonium perchlorate	70
Copper (II) oxide	15
Shellac	15

Blue star #13

Comments: Makes a bright, robins-egg blue star, with a bushy flame.

Potassium perchlorate	70
Silicone	10
Copper(II)oxide	10
PVC	15

Blue star #14

Preparation: Moisten with water, and cut into 6 mm stars. Do not prime with meal powder. Use a potassium perchlorate based prime instead.

Potassium chlorate	65
Copper oxychloride	12.5
Lactose	12.5
Dextrin	5
Saran	5

Blue star #15

Comments: Fimo is a PVC based modelling clay. The stars are brilliant blue ("Cop-lites blue"), with edges of flame tinted salmon. The stars need priming.
Preparation: Warm the Fimo slightly, to make it more mixable and mix it with the ammonium perchlorate without using solvents. Then mix in the malachite. Screen it several times and make pressed stars.

Ammonium perchlorate	70
Fimo	20
Malachite, powdered	10

Blue star #16

Potassium Perchlorate	60
Copper Carbonate	20
PVC	15
Dextrin	5

Blue star #17

Preparation: Dampen with 35% alcohol

Ammonium perchlorate	70
Copper Carbonate	15
Red gum	10
Dextrin	5

Purple star #1

Comments: Dangerous mixture since it contains both sulfur and a chlorate.
Preparation: Bind with dextrin in water. The ingredients must be very pure.

Potassium chlorate	36
Strontium sulfate	10
Copper sulfate	5
Lead chloride	2
Charcoal	2
Sulfur	12

Purple star #2

Comments: Dangerous mixture since it contains both sulfur and a chlorate.
Preparation: Bind with dextrin in water. The ingredients must be very pure.

Potassium chlorate	38
Strontium carbonate	18
Copper chloride	4
Lead chloride	2
Sulfur	14

Purple star #3

Potassium perchlorate	61.3
Red gum	9.1
Basic copper carbonate	5.0
Strontium carbonate	7.4
Parlon	12.4
Soluble glutinous rice starch	4.8

Purple star #4

Potassium perchlorate	64.0
Red gum	9.5
Copper(II)oxide	5.2
Strontium carbonate	7.8
Parlon	8.7
Soluble glutinous rice starch	4.8

Yellow star #1

Preparation: Mix dextrin with 4 volume parts of water and mix in the other ingredients.

Potassium chlorate	6
Sodium hydrogen carbonate	2
Dextrin	2

Yellow star #2

Preparation: Bind with shellac in ethanol or dextrin in water.

Potassium chlorate	8
Sodium oxalate	3
Lampblack	2

Yellow star #3

Preparation: Bind with alcohol.

Potassium chlorate	8
Sodium oxalate	4
Shellac powder	2
Dextrin	1

Yellow star #4

Potassium nitrate	48

Sulfur	24
Mealpowder	60
Charcoal	10
Rosin	2

Yellow star #5

Potassium perchlorate	68
Red gum	18
Lampblack	2
Sodium nitrate	7
Soluble glutinous rice starch	5

Yellow star #6

Preparation: The magnesium must be coated with linseed oil. Use an acetone or alcohol solvable binder.

Potassium perchlorate	45
Ultramarine	13
Magnesium, 60 mesh	30
PVC	10
Lampblack or Paulownia coal	2

Yellow star #7

Preparation: The magnesium must be coated with potassium dichromate.

Ammonium perchlorate	41
Magnesium, 60 mesh	33.3
Red gum	9.5
Ultramarine	9.5
Potassium bichromate	1.9
Soluble glutinous rice starch	4.8

Yellow star #8

Preparation: Dampen with 35% alcohol

Potassium perchlorate	70
Sodium oxalate	14
Red gum	6
Shellac	6
Dextrin	4

Yellow star #9

Preparation: Dampen with 35% alcohol

Potassium chlorate	64
Red gum or shellac	12
Fine Charcoal	1
Sodium oxalate	28
Dextrin	4

Orange star #1

Comments: Dangerous mixture since it contains both sulfur and a chlorate.
Preparation: Bind with alcohol.

Strontium nitrate	36
Sodium oxalate	8
Potassium chlorate	5
Shellac powder	5
Sulfur	3

Orange/Red star

Comments: Sculpy is PVC based modeling clay - "FIMO" will also work, but is more difficult to mix.
Preparation:

Strontium nitrate	35
Potassium perchlorate	40
"Sculpy"	22
Fe2O3	2

Salmon color star

Comments: Sculpy is PVC based modeling clay. The result is a salmon-berry (reddish-orange) color.
Preparation: Warm the sculpy slightly, to make it more mixable and mix it with the ammonium perchlorate without using solvents. Screen it several times and make pressed stars. The stars can be baked in an oven at 135°C for 20 minutes, which will result in much harder, more ignitable, more intensely colored stars. Heating the stars is not recommended though, since it could cause the stars to ignite.

Ammonium perchlorate	75
"Super Sculpy"	25

White star #1

Potassium Nitrate	58
Aluminum	40
Dextrin	2

White star #2

Potassium Perchlorate	40
Magnesium	32
Sulfur	16
Charcoal	12

White star #3

Potassium Perchlorate	2
Aluminum	1

White star #4

Barium Nitrate	53
Potassium Nitrate	12
Magnesium 100-200 mesh	28
Parlon	7
Acetone	qs
50/50 alcohol/water	qs

White star #5

Barium or Strontium Nitrate	60
Magnesium	20
PVC	20

White star #6

Potassium nitrate	59
Sulfur	30
Meal powder	11

White star #7

Potassium perchlorate	61
Aluminum	31
Lycopodium	8

White star #8

Comments: Bind with dextrin in water

Preparation:

Potassium nitrate	6
Sulfur	1
Antimony sulfide	2

White star #9

Potassium nitrate	42
Sulfur	18
Mealpowder	18

White star #10

Potassium nitrate	28
Antinony sulfide	6
Sulfur	8
Dextrin	1.5

Brilliant white star

Comments: Bind with dextrin in water

Potassium perchlorate	4
Aluminium dust	4
Dextrin	1

Orange star #2

Comments: These compositions are part of a matched set invented by Robert Veline. The compositions mix compatibly to produce a wide range of other colors. Examples are given below. The wood meal in the prime (see miscellaneous compositions) makes the stars a little 'fuzzy', making the stars much easier to ignite. Without the wood meal prime the stars are often blown blind.

Potassium Perchlorate	75
Cryolite	10
Shellac	15

Yellow star #8

Comments: These compositions are part of a matched set invented by Robert Veline. The compositions mix compatibly to produce a wide range of other colors. Examples are given below. The wood meal in the prime (see miscellaneous compositions) makes the stars a little 'fuzzy', making the stars much easier to ignite. Without the wood meal prime the stars are often blown blind.

Potassium Perchlorate	70
Cryolite	10
PVC	10
Shellac	10

Veline's red star

Comments: These compositions are part of a matched set invented by Robert Veline. The compositions mix compatibly to produce a wide range of other colors. Examples are given below. The wood meal in the prime (see miscellaneous compositions) makes the stars a little 'fuzzy', making the stars much easier to ignite. Without the wood meal prime the stars are often blown blind.
Preparation: Summary of Robert Veline's own comments: "Potassium perchlorate is a fine powder. Parlon is Hercules brand or Superchlon brand from Ishihara co. ltd. Red gum is a fine powder. Copper (II) oxide may be substituted by copper carbonate without much change in performance. Calcium carbonate is 200 mesh, 'Whiting'. More pure forms slow the burn rate and degrade the color."

Potassium perchlorate	55
Strontium carbonate	15
Parlon	15
Red gum	9
Magnalium (50/50), 200 mesh	6
Dextrin	+4

Veline's orange star

Comments: These compositions are part of a matched set invented by Robert Veline. The compositions mix compatibly to produce a wide range of other colors. Examples are given below. The wood meal in the prime (see miscellaneous compositions) makes the stars a little 'fuzzy', making the stars much easier to ignite. Without the wood meal prime the stars are often blown blind.
Preparation: Summary of Robert Veline's own comments: "Potassium perchlorate is a fine powder. Parlon is Hercules brand or Superchlon brand from Ishihara co. ltd. Red gum is a fine powder. Copper(II)oxide may be substituted by copper carbonate without much change in performance. Calcium carbonate is 200 mesh, 'Whiting'. More pure forms slow the burn rate and degrade the color."

Potassium perchlorate	55
Calcium carbonate	15
Parlon	15
Red gum	9
Magnalium (50/50), 200 mesh	6
Dextrin	+4

Veline's green star

Comments: These compositions are part of a matched set invented by Robert Veline. The compositions mix compatibly to produce a wide range of other colors. Examples are given below. The wood meal in the prime (see miscellaneous compositions) makes the stars a little 'fuzzy', making the stars much easier to ignite. Without the wood meal prime the stars are often blown blind.
Preparation: Summary of Robert Veline's own comments: "Potassium perchlorate is a fine powder. Parlon is Hercules brand or Superchlon brand from Ishihara co. ltd. Red gum is a fine powder. Copper(II)oxide may be substituted by copper carbonate without much change in performance. Calcium carbonate is 200 mesh, 'Whiting'. More pure forms slow the burn rate and degrade the color."

Potassium perchlorate	30
Barium nitrate	24
Barium carbonate	15
Parlon	15
Red gum	5
Magnalium (50/50), 200 mesh	11
Dextrin	+4

Veline's blue star

Comments: These compositions are part of a matched set invented by Robert Veline. The compositions mix compatibly to produce a wide range of other colors. Examples are given below. The wood meal in the prime (see miscellaneous compositions) makes the stars a little 'fuzzy', making the stars much easier to ignite. Without the wood meal prime the stars are often blown blind.
Preparation: Summary of Robert Veline's own comments: "Potassium perchlorate is a fine powder. Parlon is Hercules brand or Superchlon brand from Ishihara co. ltd. Red gum is a fine powder. Copper(II)oxide may be substituted by copper carbonate without much change in performance. Calcium carbonate is 200 mesh, 'Whiting'. More pure forms slow the burn rate and degrade the color."

Potassium perchlorate	55
Copper(II)oxide	15
Parlon	15
Red gum	9
Magnalium (50/50), 200 mesh	6
Dextrin	+4

Veline's mixed colors

Comments: These are a few examples of the colors that can be obtained by mixing a few of Robert Veline's set of star compositions.

Yellow	55 green, 45 orange
Chartreuse	80 green, 20 orange
Aqua	80 green,20 blue

Turquoise..55 green, 45 blue
Magenta..50 red, 50 blue
Maroon...85 red, 15 blue
Peach..60 orange, 25 red, 15 blue
Purple...5 orange, 15 red, 80 blue

9

Effect Stars

White flare star

Comments: Dangerous mixture since it contains both sulfur and a chlorate.
Preparation: Wet with solution of shellac in ethanol. ±20g Shellac per liter of ethanol.

Potassium nitrate................................165
Sulfur...31
Barium nitrate..................................455
Barium chlorate..................................31
Magnesium powder.................................18
Aluminum medium course...........................5
Aluminum fine...................................25

Gold flitter star

Comments: The particle sizes of aluminum powders will markedly affect the result. If Al bronze is available, you can use all 16 parts of it instead of the two different Al powders.
Preparation: Add water and proceed as usual.

Potassium nitrate, fine..........................16
Sulfur...3
Charcoal, powdered...............................2
Sodium oxalate or Ultramarine....................4 or 2
Fine, grey aluminum powder (preferably pyro Aluminum).....11
Flake Aluminum or medium Al powder (Al bronze works well).....5
Dextrin...4

Zinc spreader star #1

Comments: The stars spread pieces of burning zinc and charcoal. These stars are much heavier than usual, and require larger lifter charges if they're to be fired from a tube.
Preparation: Bind with water.

Zinc dust	72
Potassium chlorate	15
Potassium dichromate	12
Granular charcoal	12
Dextrin	2

Zinc spreader star #2

Preparation: Bind with dextrin in water.

Potassium nitrate	14
Zinc dust	40
Charcoal	7
Sulfur	4

Zinc spreader star #3

Comments: Bind with dextrin in water.

Potassium chlorate	5
Potassium dichromate	4
Charcoal, medium	4
Zinc dust	24

Willow tree star

Comments: Dangerous mixture since it contains both sulfur and a chlorate.
Preparation: Bind with dextrin in water.

Potassium chlorate	10
Potassium nitrate	5
Sulfur	1
Lampblack	18

Soft willow lampblack star

Preparation: Use a meal powder prime. 1 part shellac can be used instead of 5 parts, burning time will be reduced by 2 sec. Standard willow method: mix the components, wet with alcohol/water screen pulverone style, dry, mill for 3 hours then make cut stars. Adding extra charcoal might slow the burn, giving a better tail.

Charcoal	25
Dextrin	5
Potassium nitrate	10
Potassium perchlorate	30

Lampblack	30
Shellac	5

Lampblack willow star

Preparation: Dampen with 50/50 water/alcohol as it is rolled over a (chlorate) core star or stars containing NO sulfur or sulfur compounds. It helps to slightly dampen the lampblack with pure alcohol before it is mixed with the other dry ingredients. Once thoroughly mixed, it should still flow as a powder, or too much alcohol was used. If that happens, allow it to evaporate for awhile until it can be sprinkled on the rolling stars.

Lampblack	12
Potassium chlorate	8
Potassium nitrate	1
Dextrin	1

Silver shower star #1

Preparation: Add water and proceed as usual. The particle size and surface area of the reactants has a profound effect on the results.

Potassium nitrate	35
Fine charcoal	8
Boric acid	2
Sulfur	7
Potassium perchlorate	60
Fine pyro Aluminum (atomised Aluminum, 0.1 mm)	20
Fine flake aluminum (Al bronze)	25
Coarse flake Aluminum	15
Dextrin	10

Silver shower star #2

Comments: The particle size of the aluminum is not very critical.
Preparation: Dissolve shellac in boiling ethanol, mix in the other ingredients and proceed as usual. Shellac stars take a long time to dry; try drying in the sun. Prime with a perchlorate based strobe prime.

Ammonium perchlorate	65
Fine aluminum powder or flake aluminum (not too coarse)	22
Shellac	18

Silver shower star #3

Preparation: Add water and proceed as usual.

Flitter Aluminum (or any grade except the finest pyro grades)	15
Potassium nitrate	55
Boric acid	2
Fine charcoal	10
Dextrin	5

Electric star #1

Preparation: Bind with dextrin in water.

Potassium nitrate	15
Aluminum, fine	2
Aluminum, medium	1
Black powder	2
Antimony sulfide	3
Sulfur	4

Electric star #2

Preparation: Bind with red gum in water.

Potassium chlorate	60
Barium nitrate	5
Aluminum, fine	9
Aluminum, medium	4
Aluminum, coarse	3
Charcoal	2
Dextrin	5

Electric star #3

Preparation: Bind with shellac in alcohol.

Potassium perchlorate	6
Barium nitrate	1
Aluminum	20
Dextrin	1

Electric star #4

Preparation: Bind with shellac in alcohol.

Potassium perchlorate	4
Aluminum, medium	2
Dextrin	1

Firefly #1

Preparation: Aluminum is large flake. It was sieved through a window screen. This gives about 30 mesh powder.

Potassium nitrate	50
Charcoal, air float	29
Charcoal, 80 mesh	10.5
Sulfur	6
Aluminum (large flake)	4.5
Dextrin or CMC	+5 or +1

Firefly #2

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Comments: Can also be used as rocket propellant: Mix the chemicals, dampen, and granulate through a 20 mesh screen and dry. Use +3% by weight as a tail effect. Once you have passed the top core of the rocket by 1/2 inch, you may ram 100% firefly formula the rest of the way. You will end up with a beautiful long trailing tail of firefly.

Potassium Nitrate	47
Air Float Charcoal	33
Antimony tri-sulfide	5.8
Aluminum (400 mesh,12 micron, spherical)	4.2
Sulfur	4.7
Dextrin	5.2

Firefly #3

Preparation: Ball mill potassium nitrate, Air Float charcoal, sulfur and Dextrin together for 1 hour. Then add the 36 mesh Charcoal and firefly aluminum and mix with a spoon. Add water to make a dough mix and cut with a knife into 3/8" cut stars. Separate stars and dry for 3-4 days. The effect is a long tiger tail going up and firefly sparkles coming down. Larger stars take longer to dry, and a damp star produces very little firefly effect

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Potassium nitrate	49
Charcoal, air float	29
Charcoal, 36 Mesh	11
Sulfur	9
Dextrin	10
Aluminum, firefly	5

Glitter star

Preparation: Wet with ethanol/water (70/30)

Potassium nitrate	55
Aluminum 200-400 mesh	5
Dextrin	4
Antimony(III)sulfide	16
Sulfur	10
Lampblack	10

Red Pill Box star

Potassium chlorate	64
Strontium carbonate	19
Red gum	13
Dextrin	4

Sparkler star

Potassium perchlorate	60
Aluminum, course	30
Dextrin	10

White flitter star

Potassium nitrate	17
Sulfur	3
Charcoal	3
Aluminum, course	4
Aluminum flake, fine	10
Dextrin	1

White comet #1

Potassium nitrate	96
Fine charcoal	44
Sulfur	15
Dextrin	10

White comet #2

Potassium nitrate	40
Fine charcoal	24
Sulfur	8
Dextrin	9

'Dragon eggs' star (Crackling star)

Comments: Sometimes, Bi_2O_3 is used instead of Pb_3O_4. The composition is extremely sensitive,

both to friction and impact. It is also quite poisonous and explosive. Gloves and an air mask must be worn at all times when handling this mixture since the mixture contains the very toxic Pb_3O_4.
Preparation: Add lacquer until the thickness is like wood putty. Pass the mix through a screen and dry it to make 1mm squares. These will explode with a sharp crack shortly after lighting and can be used as star cores.

Pb_3O_4	81.8
Magnalium (50/50, 100-200 Mesh)	9.1
Copper(II)oxide	9.1
Nitrocellulose lacquer binder	10% by volume

Blue star with charcoal tail

Preparation: Add isopropyl alcohol for binding. Cut, round and pumped stars can be made with this composition, but a typical $KClO_4$/Red gum/Charcoal/dextrin prime will be necessary. A final layer of sodium nitrate/sulfur/Charcoal (85/5/10), moistened with NC/acetone lacker (w. about 3% NC) can be added. This adds yellowish sparks. Mealpowder can be used instead if the yellow sparks are not desired.

Ammonium perchlorate	70
Basic copper carbonate	10
Red Gum	10
Charcoal	10
Dextrin	+5

Electric purple star

Comments: When very fine powdered ammonium perchlorate was used in an attempt to try to increase the burning rate of stars an ammoniacal smell and an increase in temperature was noticed. The batch of stars was safely disposed of. By adding 5% potassium dichromate and 1% boric acid the reactions were prevented.

Ammonium perchlorate	68
Copper benzoate	8
Strontium carbonate	12
Magnalium (200-400 Mesh)	5
Hexamine	7
Dextrin	+5

Brilliant core

Comments: This composition can be used for the cores of round stars. It gives a strong flash of light. The cores burn quickly and are self propelled when they are unevenly ignited. To prevent that, these cores should be coated with 'Brilliant core prime' (see miscellaneous compositions) until they are round.

Barium nitrate...................................66
Aluminum, fine flake.............................27
Boric acid.......................................1
Soluble glutinous rice starch.....................6

Silver star core

Comments: This composition can be used for the cores of round stars. It burns less quickly than the 'brilliant core', and produces a silver flame.

Potassium perchlorate............................56
Rosin (BL combustion agent).......................5
Aluminum (fine flake)............................32
Lampblack..2
Soluble glutinous rice starch.....................5

Silver wave

Comments: This composition produces a silver fire dust. A large silver fire dust flame of short duration is obtained. When the ratio perchlorate to aluminum is changed to 35/65 a small flame with yellowish fire dust of long duration is obtained.

Potassium perchlorate............................50
Aluminum (somewhat coarse flake)..................50
Soluble glutinous rice starch.....................+5%

Golden wave #1

Potassium nitrate................................37
Aluminum (somewhat coarse flake)..................47
Antimony trisulfide..............................9
Boric acid.......................................1
Soluble glutinous rice starch.....................6

Golden wave #2

Potassium nitrate................................37
Aluminum (somewhat coarse flake)..................47
Sulfur...9
Boric acid.......................................1
Soluble glutinous rice starch.....................6

Golden wave #3

Comments: A somewhat reddish gold effect is obtained with this composition.

Potassium nitrate.................................37
Aluminum (somewhat coarse flake)..................47
Realgar...9
Boric acid..1
Soluble glutinous rice starch.....................6

Golden chrysanthemum

Comments: This produces a brilliant yellow fire dust.

Potassium nitrate.................................40
Aluminum (somewhat coarse flake)..................30
Sulfur..10
Realgar...10
Hemp coal (or pauownia coal)......................2
Boric acid..1
Soluble glutinous rice starch.....................7

Charcoal fire dust #1

Comments: A reddish fire dust is obtained, which is relatively short-lived. When willow charcoal is used instead of pine, long lived fire dust is obtained.
Preparation: To obtain the fire dust, the potassium nitrate must be soaked into the charcoal. Hence a wet process must be used for mixing.

Potassium nitrate.................................55
Sulfur..7
Pine charcoal.....................................33
Soluble glutinous rice starch.....................5

Charcoal fire dust #2

Comments: A reddish fire dust is obtained, which is relatively short-lived. When willow charcoal is used instead of pine, long lived fire dust is obtained.
Preparation: To obtain the fire dust, the potassium nitrate must be soaked into the charcoal. Hence a wet process must be used for mixing.
Preparation: Potassium nitrate....................49
Sulfur..6
Pine charcoal.....................................40
Soluble glutinous rice starch.....................5

Charcoal fire dust #3

Comments: A weak fire dust is obtained since the composition contains no sulfur. It creates a different and lonely effect.

Preparation: To obtain the fire dust, the potassium nitrate must be soaked into the charcoal. Hence a wet process must be used for mixing.

Potassium nitrate	45
Pine charcoal	50
Soluble glutinous rice starch	5

Charcoal fire dust #4

Preparation: To obtain the fire dust, the potassium nitrate must be soaked into the charcoal. Hence a wet process must be used for mixing.

Potassium nitrate	44
Sulfur	6
Pine charcoal	44
Soluble glutinous rice starch	6

Charcoal fire dust #5

Preparation: To obtain the fire dust, the potassium nitrate must be soaked into the charcoal. Hence a wet process must be used for mixing.

Potassium nitrate	35
Sulfur	12
Pine charcoal	45
Soluble glutinous rice starch	8

Silver wave chrysanthemum

Comments: A fire dust with sparks from the metal powder is obtained. It looks as if red, yellow and green twinkling fire particles were mixed together.
Preparation: The potassium nitrate, sulfur and pine charcoal are previously mixed densely as in the manufacture of black powder.

Potassium nitrate	50
Sulfur	17.5
Pine charcoal	7.5
Aluminum (somewhat coarse flake)	7.5
Magnalium	1.5
Antimony trisulfude	2.5
Realgar	7.5
Soluble glutinous rice starch	6.0

Metal fire dust No.32

Potassium nitrate	38

Sulfur..13
Charcoal..10
Barium nitrate...................................14
Aluminum, Atomized................................12
Red Iron Oxide, Fe2O3.............................8
Dextrin...5

Metal fire dust No.33

Potassium nitrate.................................43
Sulfur..10
Charcoal..10
Barium nitrate...................................13
Aluminum, Atomized................................13
Red Iron Oxide, Fe2O3.............................7
Dextrin...4

Metal fire dust No.34

Potassium nitrate.................................40
Sulfur..10
Charcoal..10
Barium nitrate...................................16
Aluminum, Atomized................................12
Red Iron Oxide, Fe2O3.............................7
Dextrin...5

Metal fire dust No.35

Potassium nitrate.................................36
Sulfur..13
Charcoal..10
Barium nitrate...................................16
Aluminum, Atomized................................12
Red Iron Oxide, Fe2O3.............................8
Dextrin...5

Metal fire dust No.38

Potassium nitrate.................................40
Sulfur..12
Charcoal..12
Barium nitrate...................................13
Aluminum, Atomized................................12
Red Iron Oxide, Fe2O3.............................7
Dextrin...4

Matrix comet composition #1

Comments: A matrix comet consists of a matrix composition in which colored microstars are embedded. It produces a colored tail when fired. The microstars must be slow-burning while the matrix must be very fast burning. The matrix must either emit as little light as possible or a lot of light in a color that is compatible with the color of the microstars. The following green matrix composition from c1995 is a good starting point for further experimentation.
Preparation: Exfoliated mica is also called Vermiculite. It is usually obtained from 'mineral products' suppliers in graded sizes from around 5 to 10 millimeters. It requires combination in a coffee mill, followed by screening. The guar binder, although very effective in low amounts, has a very slow drying profile and a tendency to produce a 'skin' that prevents 'radiant heat source' drying. To dry the comets uniformly requires a fan circulated 'dry air' drier. Large 3" comets might take two months to dry properly depending on the circumstances.

Potassium chlorate, passing 200 mesh	50
Barium benzoate, passing 100 mesh	23
Barium carbonate, passing 200 mesh	10
Exfoliated mica, pass 80 mesh, hold 120 mesh	10
Bentonite clay - wyoming, passing 200 mesh	6
Guar gum fine WW250F, passing 200 mesh	1

Matrix comet composition #2

Comments: A matrix comet consists of a matrix composition in which colored microstars are embedded. It produces a colored tail when fired. The microstars must be slow-burning while the matrix must be very fast burning. The matrix must either emit as little light as possible or a lot of light in a color that is compatible with the color of the microstars. The following green matrix composition from c1995 is a good starting point for further experimentation.
Preparation: Exfoliated mica is also called Vermiculite. It is usually obtained from 'mineral products' suppliers in graded sizes from around 5 to 10 millimeters. It requires combination in a coffee mill, followed by screening. The guar binder, although very effective in low amounts, has a very slow drying profile and a tendency to produce a 'skin' that prevents 'radiant heat source' drying. To dry the comets uniformly requires a fan circulated 'dry air' drier. Large 3" comets might take two months to dry properly depending on the circumstances.

Potasium perchlorate, passing 100 mesh	50
Zirconium silicate, passing 325 mesh	30
Polykarbenite-3 - Armex, passing 200 mesh	10
Barium carbonate, passing 200 mesh	9
Guar gum fine WW250F, passing 200 mesh	1

10

Strobe Stars

Twinkling green star #1

Comments: Magnesium reacts slowly with ammonium perchlorate producing ammonia and magnesium perchlorate, especially in the presence of moisture. Thus, the twinklers cannot be stored for more than 6 months, and they must be kept in a closed bag. During the smolder phase, magnesium reacts with ammonium perchlorate in the dark. In the flash phase, magnesium reacts with barium sulfate, producing hot MgO and creating a green flame. The flash is followed by another cycle, since the flash rapidly consumes the reactants in the flash zone.
Preparation: 1) Binder solution: Dissolve 3 parts of nitrocellulose (smokeless powder or celluloid film) into 30 parts (w/v) of boiling acetone. If you're going to prepare these stars more than once, prepare more of the solution, since nitrocellulose dissolves slowly even in refluxing acetone. Approx. 30 parts of the solution (v/w) is used each time. Nitrocellulose is used as a binder, since other binders tend to interfere with the twinkling. 2) Mix the ingredients into the binder solution in the order they appear here. Proceed as usual. Note that acetone evaporates very rapidly and the stars usually dry within a few hours.

Magnesium powder (any lab grade powder)	23
Ammonium perchlorate	60
Barium sulfate	17

Twinkling green star #2

Comments: Frequently: 3.1 Hz.
Preparation: Add 25 parts 10% nitrocellulose solution in acetone to 100 parts of the composition, and make cut stars. Roll these stars in "priming composition #8", using the same NC paste until stars are round. Add a final layer of black powder in NC paste to ensure ignition.

Magnesium, 60 mesh (treated with potassium bichromate)	23
Ammonium perchlorate	60
Barium sulfate	17
Potassium dichromate (as a stabilizer)	+5%

Twinkling green star #3

Preparation: Add 25 parts 10% nitrocellulose solution in acetone to 100 parts of the composition, and make cut stars. Roll these stars in "priming composition #8", using the same NC paste until stars are round. Add a final layer of black powder in NC paste to ensure ignition.

Magnalium..18 (coated with linseed oil) Barium nitrate[40
BHC (Benzene hexachloride).......................5
Sulfur...30
Antimony trisulfide..............................7
•Twinkling red star Class:10.....................50

Twinkling red star

Preparation: Magnesium was treated with cold 10% w/w K2Cr2O7 in de-ionized water for 2 hours.

Ammonium perchlorate, 100 mesh...................50
Magnesium metal, 120 mesh........................23
Strontium sulfate, 100 mesh......................18
Genchlor GC 700-200, 160 mesh....................2
Winchester DB-231 as grain pwd...................7
Acetone, water free technical....................+20% (w/w)

Twinkling white star #1

Preparation: The magnalium needs to be treated with potassium dichromate before mixing.

Barium nitrate...................................51
Sulfur...19
Magnalium, 100 Mesh..............................18
Potassium nitrate................................7
Dextrin..5

Twinkling white star #2

Comments: Frequency: 9.7 Hz.
Preparation: Add 25 parts 10% nitrocellulose solution in acetone to 100 parts of the composition, and make cut stars. Roll these stars in "priming composition #8", using the same NC paste until stars are round. Add a final layer of black powder in NC paste to ensure ignition.

Magnalium, 80 mesh (treated with potassium bichromate).....25
Ammonium perchlorate.............................60
Barium sulfate...................................15
Potassium dichromate (as a stabilizer)...........+5%

Twinkling red star

Comments: Frequency: 3.5 Hz.
Preparation: Add 25 parts 10% nitrocellulose solution in acetone to 100 parts of the composition, and make cut stars. Roll these stars in "priming composition #8", using the same NC paste until stars are round. Add a final layer of black powder in NC paste to ensure ignition.

Magnesium, 60 mesh (treated with potassium bichromate).....30
Ammonium perchlorate.............................50
Strontium sulfate................................20
Potassium dichromate (as a stabilizer)...........+5%

Twinkling orange star

Comments: Frequency: 6.9 Hz.
Preparation: Add 25 parts 10% nitrocellulose solution in acetone to 100 parts of the composition, and make cut stars. Roll these stars in "priming composition #8", using the same NC paste until stars are round. Add a final layer of black powder in NC paste to ensure ignition.

Magnesium, 60 mesh (treated with potassium bichromate).....30
Ammonium perchlorate.............................60
Calcium sulfate..................................10
Potassium dichromate (as a stabilizer)...........+5%

Twinkling yellow star #1

Comments: Frequency: 3.5 Hz.
Preparation: Add 25 parts 10% nitrocellulose solution in acetone to 100 parts of the composition, and make cut stars. Roll these stars in "priming composition #8", using the same NC paste until stars are round. Add a final layer of black powder in NC paste to ensure ignition.

Magnesium, 60 mesh (treated with potassium bichromate).....40
Ammonium perchlorate.............................50
Sodium sulfate...................................10
Potassium dichromate (as a stabilizer)...........+5%

Twinkling yellow star #2

Preparation: Add 25 parts 10% nitrocellulose solution in acetone to 100 parts of the composition, and make cut stars. Roll these stars in "priming composition #8", using the same NC paste until stars are round. Add a final layer of black powder in NC paste to ensure ignition.

Magnalium (coated with linseed oil)...............12
Barium nitrate...................................33
Potassium nitrate................................7
BHC (Benzene hexachloride).......................11
Sulfur...27

Antimony trisulfide..............................5
Sodium oxalate...................................5

Twinkling blue star

Preparation: Add 25 parts 10% nitrocellulose solution in acetone to 100 parts of the composition, and make cut stars. Roll these stars in "priming composition #8", using the same NC paste until stars are round. Add a final layer of black powder in NC paste to ensure ignition.

Magnesium, 60 mesh (treated with potassium bichromate).....23
Ammonium perchlorate.............................60
Copper sulfate...................................17
Potassium dichromate (as a stabilizer)...........+5%

Golden twinkler star

Comments: Bind with water. The stars fall through the air and burn in an "on and off" manner. The effect is spectacular.
Preparation: The stars must be pumped or cut.

Potassium nitrate................................18
Sulfur...3
Lampblack..3
Aluminum...3
Antimony sulfide.................................3
Sodium oxalate...................................4

11

Smoke Stars

Red smoke star

Preparation: Wheat flour can be substituted for milk sugar. Produce as 10mm cut stars, and prime with meal powder.

Potassium chlorate	28
Milk sugar	20
Rhodamine B conc	30
Oil orange	22
Soluble glutinous rice starch	+3%

Yellow smoke star #1

Comments: The smoke is denser than that of dye smoke, but it looks dark yellow against the light of the sun. The smoke is poisonous.
Preparation: Make pressed stars.

Potassium nitrate	25
Sulfur	16
Realgar	59

Yellow smoke star #2

:

Potassium nitrate	48.5
Sulfur	48.5
Realgar	3
Charcoal (or hemp coal)	+2%
Soluble glutinous rice starch	+6%

Yellow smoke star #3

Preparation: Form into cut stars, and dry them well. Place them in a coating tub. Add slurry of soluble glutinous rice starch and cover all the surfaces with the paste by shaking the tub. Remove from the tub and place them on gypsum powder. Roll them in it until all the stars are coated with the gypsum. Dry in the sun. Repeat these operations until the layer of gypsum becomes thicker than 1.5mm. It will be necessary to repeat at least 6 times. When done, bore a hole in each star to introduce the fire in it (with appropriate precautions taken). Prime the hole with black powder paste and dry in the sun. Roll a final layer of soluble glutinous rice starch and meal powder over the stars and dry them thoroughly.

Potassium nitrate................................43
Sulfur...10
Realgar..37
Hemp coal (or Paulownia coal)....................4
Soluble glutinous rice starch....................6

Green smoke star

Preparation: Wheat flour can be substituted for milk sugar. Produce as 10mm cut stars, and prime with meal powder.

Potassium chlorate...............................33
Milk sugar.......................................27
Oil yellow (Butter yellow)........................20
Phthalocyanine blue..............................20
Soluble glutinous rice starch....................+3%

Blue smoke star

Preparation: Wheat flour can be substituted for milk sugar. Produce as 10mm cut stars, and prime with meal powder.

Potassium chlorate...............................33
Milk sugar.......................................27
Phthalocyanine blue..............................40
Soluble glutinous rice starch....................+3%

Violet smoke star

Preparation: Wheat flour can be substituted for milk sugar. Produce as 10mm cut stars, and prime with meal powder.

Potassium chlorate...............................29
Milk sugar.......................................25
Rhodamine B conc.................................13
Oil orange.......................................16
Phthalocyanine blue..............................17
Soluble glutinous rice starch....................+3%

White smoke star #1

Potassium nitrate	53
Sulfur	7
Charcoal (or hemp coal)	32
Lampblack	8
Soluble glutinous rice starch	+6%

White smoke star #2

Potassium nitrate	66
Realgar	13
Charcoal (or hemp coal)	5
Lampblack	5
Soluble glutinous rice starch	11

White smoke star #3

Comments: The smoke is caused by condensation of sulfur vapor.
Preparation: Form into cut stars, and dry them well. Place them in a coating tub. Add slurry of soluble glutinous rice starch and cover all the surfaces with the paste by shaking the tub. Remove from the tub and place them on gypsum powder. Roll them in it until all the stars are coated with the gypsum. Dry in the sun. Repeat these operations until the layer of gypsum becomes thicker than 1.5mm. It will be necessary to repeat 6 times. When done, bore a hole in each star to introduce the fire in it (with appropriate precautions taken). Prime the hole with black powder paste and dry in the sun. Roll a final layer of soluble glutinous rice starch and meal powder over the stars and dry them thoroughly.

Potassium nitrate	48.5
Sulfur	48.5
Realgar	3
Charcoal (or hemp coal)	+2%
Soluble glutinous rice starch	+6%

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Flash Powder,Firecrackers,Cherry Bombs, M-80s, etc.

The Invention of the Firecracker

In the Han Dynasty (206-220 BC) it is said that people would roast bamboo to produce a load sound that was intended to disperse ghosts and apparitions. In the Northern and Southern Dynasties (420-581 AD) this kind of sound was not only used to dispel evil but also to pray for happiness and prosperity.

At the end of the Northern Song Dynasty, the first paper tube crackers, filled with gunpowder, were produced. Crackers strung together by hemp rope, known as 'hundred-break' crackers, appeared at the end of the Southern Dynasty (fifth Century AD). Li Tian is credited as the originator of the cracker industry.

Li Tian, the Founder

There was an emperor named Li Shiming in the Tang Dynasty (618-907 AD). His Prime Minister, Wei Zhou, killed an evil dragon, which then came back to haunt him. He was greatly vexed and did not know what to do. Li Tian ignited a bamboo tube that was filled with a pyrotechnic composition. The ghost was frightened by the loud bang and went away. After that, the people called Li Tian the founder of crackers and every April 18th they offer sacrifices to him.

It was said that in the Zhenguan period of the Tang Dynasty, in the east of Hunan Province there were floods and droughts every year. Li Tian went to Liu Yang and was struck by the people's poverty. He set off fireworks to disperse the evil, after which, the people lived and worked in peace and prosperity. In the Song Dynasty (980-1271 AD) people set up a temple to worship Li Tian.

The Development of the Firecracker

At the end of the Sui Dynasty (581-618 AD), beginning of the Tang (618-907 AD), the famous alchemist and medicine man Sun Si Miao refined ore in a cave near the eastern side of Liu Yang, Hunan. He developed crackers and later, fireworks. His tools and workbench have been preserved to this day.

At the end of the Northern Song and the beginning of the Southern Song dynasties, firecrackers made rapid progress along side the development of social, economic and chemical sciences. In the Qing Dynasty (1644-1911 AD) firecrackers were presented to the palace as articles of tribute and were greatly enjoyed by the dignitaries of the court.

Fireworks Export

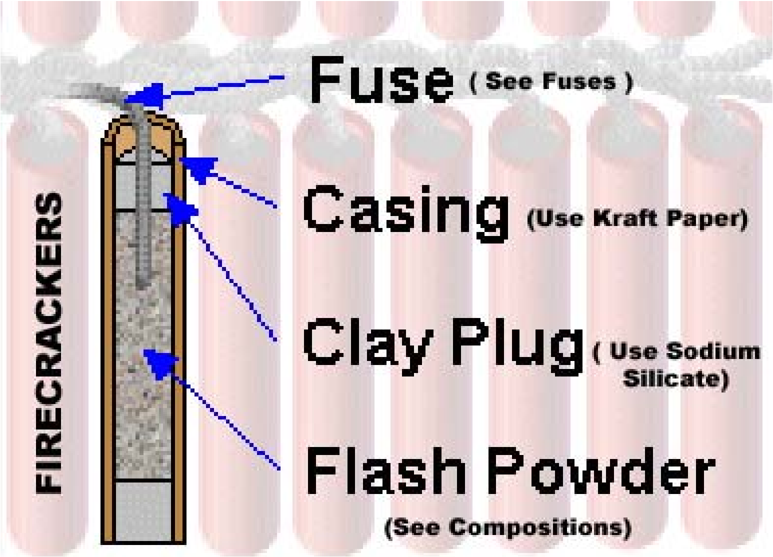
The export of fireworks began with Paozhuang, a private trading company, which had a main store and several branches. In the mid-1800's, Paozhuang began to deal in fireworks, trading by land and sea, throughout Asia and as far as Europe.

Fireworks were sold abroad in the Guangxun Period (1875-1908 AD) of the Qing Dynasty (1644-1911 AD). At first, fireworks were transported to Guangdong, then to Hong Kong or Macao where they were collected for sale and distribution to Southeast Asia. Some were also sold abroad from Shanghai. During the Xuantong Period (1909-1911 AD) fireworks were sold in twenty countries, including Singapore, India, Korea, Japan, Russia, the Philippines, Britain, America, Sweden, Egypt, Canada, Australia and other Latin America countries.

The Depression of the 1930s and World War II disrupted the firecracker industry greatly. First the economy collapsed, and the discretionary income that fueled the firecracker business nearly disappeared. By the time the economy was recovering, World War II interrupted trade with the Far East. The Chinese firecracker trade was a part of that business. Furthermore, many fireworks manufacturers switched to producing war materials and never returned to producing civilian fireworks. Legislation was passed that prohibited the old giant cannon crackers. Taxes assessed on the imported crackers effectively limited their size to less than 2 inches in length. There was a brief resurgence in the firecracker business during the 1950s and 1960s, but by then the antifireworks lobbies were ascendant, and the firecracker business seemed under attack from all sides. The mid-1960s saw firecrackers reduced in size again to a maximum powder load of 2 grains (130 milligrams). In the 1960s and 1970s, antifireworks legislation passed at the federal level severely crippled the domestic fireworks industry—at least the part that produced firecrackers and other "family" fireworks. Normalization of relations with the People's Republic of China by the Nixon administration in the early 1970s hooded the fireworks market with incredibly cheap Chinese fireworks, and there was just no way for domestic producers to compete effectively. The U.S. government in 1977 further reduced the maximum load in firecrackers to a tiny 50 milligrams. Thus, from the 1970s on, small, "consumer" fireworks— that is, "Class C" goods have been made predominantly (again) by the Chinese. While many inside the fireworks community blame the "liberals" for passage of restrictive fireworks legislation, the fact is that the business doesn't seem to have fared much better in the last decade under the conservative Reagan and Bush administrations. American government just seems to have a prohibition mentality, to which the fireworks business has fallen victim. The illegal fireworks business presents so many opportunities for the criminal entrepreneur that it is also doubtful that the merit will ever effectively prohibit the firecracker business. At present the business in illegal firecrackers and ever more gigantic flash salutes is more prevalent in the weeks before July 4 than it ever was before the crackdown on the old M-80s and cherry bombs.

In current years, the fireworks export industry has opened to an expanding market. At present, few countries do not import Chinese made fireworks.

Presently, there are five bases of fireworks production in China: Liuyan (Hunnan), Beihai (Guangxi), Pingxiang (Jiangxi), Jianghu (Jiangsu), and Donguan (Guangdong).


FIRECRACKERS
Fuse (See Fuses)
Casing (Use Kraft Paper)
Clay Plug (Use Sodium Silicate)
Flash Powder (See Compositions)

The Development of Safety Systems

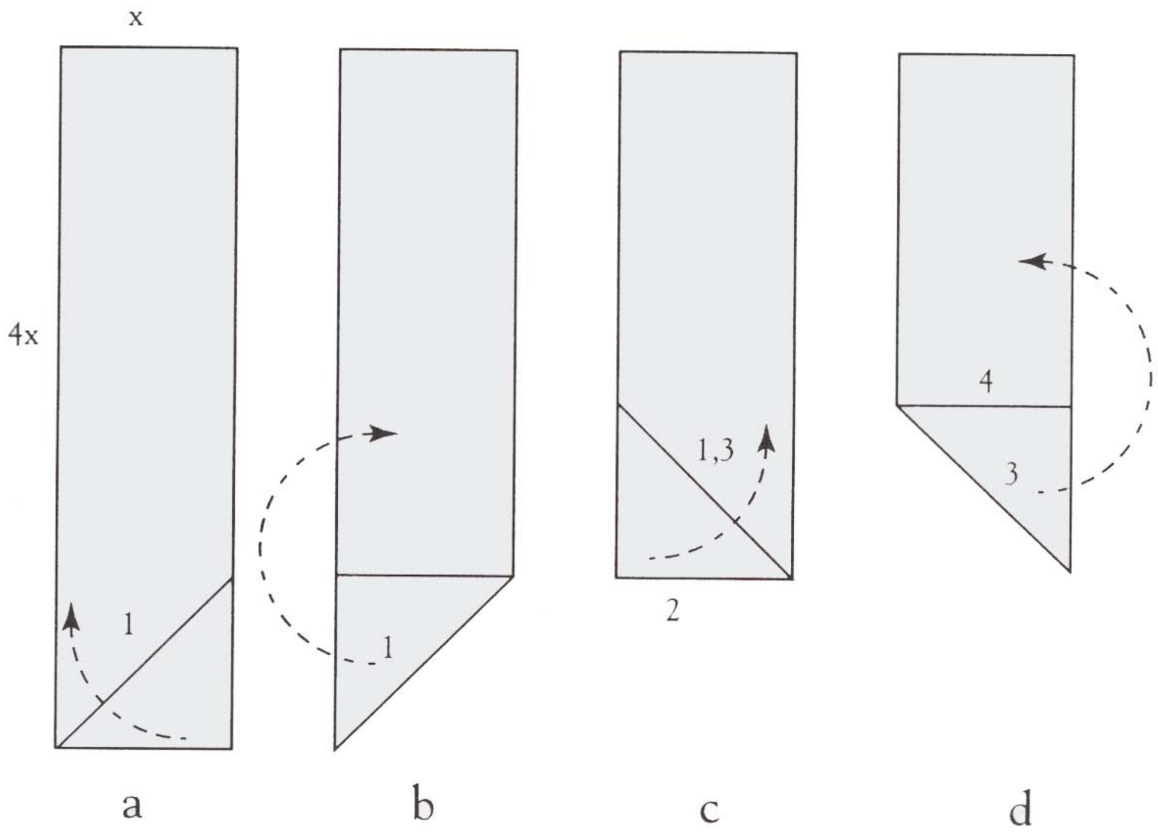
Throughout the development of the fireworks industry, safety standards have become increasingly important.

The Department of Consumer Product Inspection of China has issued national standards for fireworks and firecrackers, outlining requirements for both safety and quality. These safety regulations were implemented, and explosive accidents have been reduced greatly.

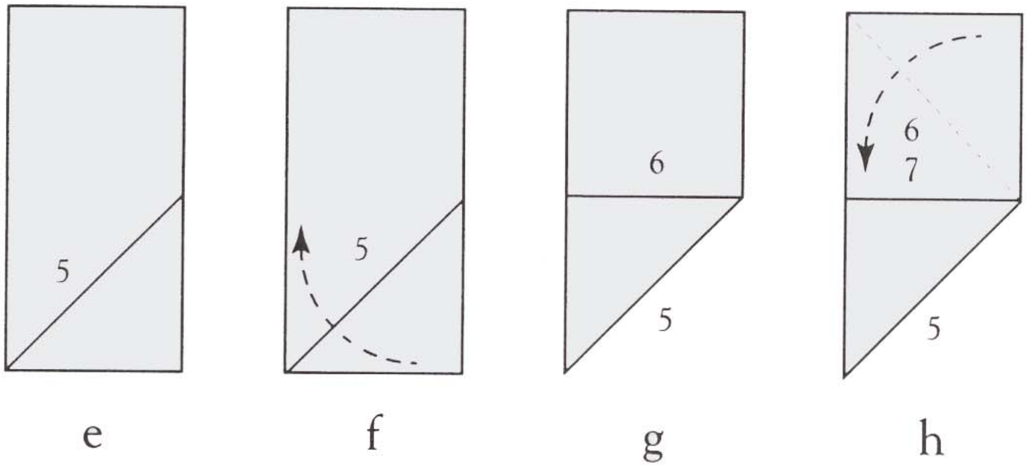
Most of the fireworks factories in China that are shipping fireworks to the USA are now involved in the China Fireworks Quality Improvement Program (QIP). This is part of the testing program set up by the American Fireworks Standards Laboratory (AFSL). The goals of the program are to improve the quality and safety of fireworks distributed in the United States and this will obviously affect the quality of products shipped worldwide.

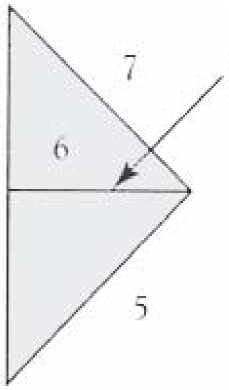
The development of superior safety systems has improved fireworks quality and guarantees the future of the fireworks industry.

THE SIMPLE TRIANGLE CRACKER

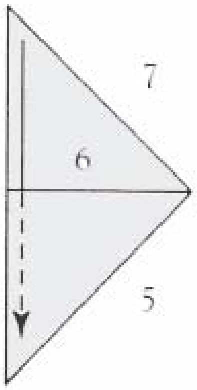


The triangle cracker is formed from a rectangular sheet of paper folded into repeating isosceles right triangles, much like flags are often folded. the first triangle, formed by fold 1 in diagram "a" sets the pattern for the rest. Repeat folds as shown in diagrams.

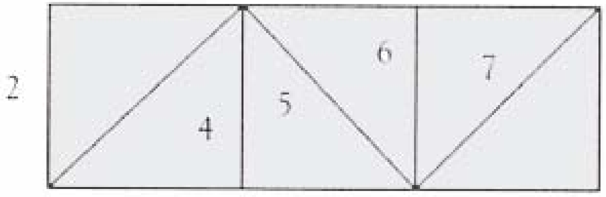




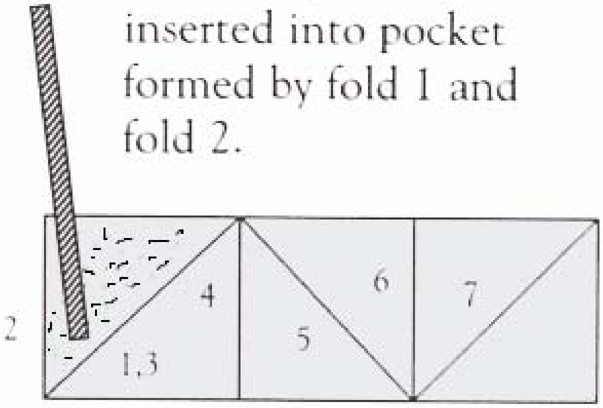
Flap into which tab formed by fold 7 is inserted.



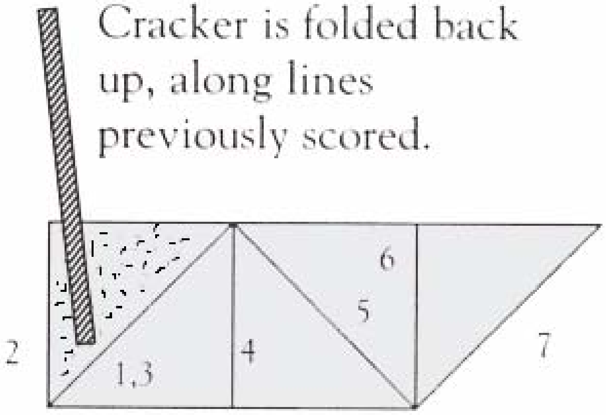
The paper, folded as shown below, with first two folds in place is ready to load and fuse



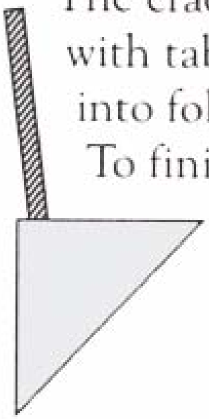
Fuse and powder are inserted into pocket formed by fold 1 and fold 2.

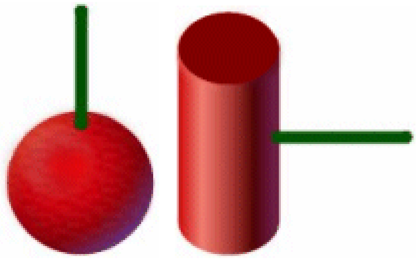


Cracker is folded back up, along lines previously scored.



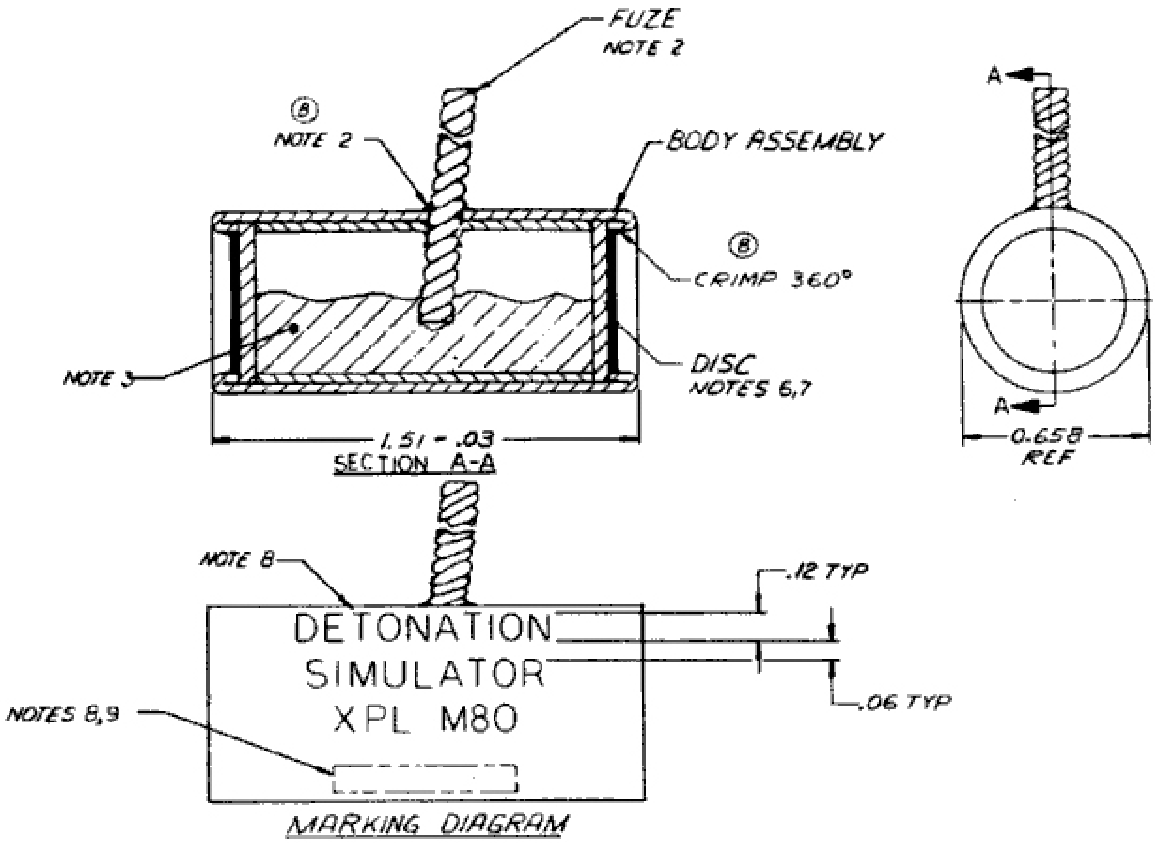
The cracker is refolded, with tab of fold 7 inserted into fold, sealing cracker. To finish, cracker is wrapped with pasted paper.





The Original M-80 was a military training device designed to simulate small arms fire in basic training. The "M-80" designation was a military product identification code number like M-16 or M-9. The U.S. government contracted with several fireworks makers to produce these hefty salutes. Military issue M80s are made from a plain, brown Kraft paper tube 1 ½ inch long, and 9/16 inch inside diameter, using a stiff, green or red visco fuse and packaged in boxes of 50. Each box is hermetically sealed in foil-backed cloth packaging. Each salute bears the words "M-80 Firecracker" and the date of manufacture "4-64." Careful dissection reveals that each firecracker is double plugged at each end with a paper disk and an end cap. The M80s are filled completely, with no air space, using a dark flash mixture. This differs from most flash salutes, which function optimally with some air space and loose powder. Perhaps this was done because of some government specification that had little to do with performance. From a standpoint of design, these are odd firecrackers. After World War II the M-80 was marketed as a fireworks item for civilian use. The first ones on the market were war surplus, the genuine articles. When some of the fireworks dealers saw how well they were received by the public, they began making civilian copies. These copies were sold by the millions in the 1950s and 1960s. The usual civilian M-80 had a red tube of the original dimensions, bearing the words "M80 FIRECRACKER DO NOT HOLD IN HAND" printed on the outside in bold letters. The pyrotechnic hobbyist can make the original M-80 follows the same procedure as other M-80s, except he uses the larger 9/16 inch inside diameter tubes and corresponding plugs. One can use either ordinary flash, or one of the following three formulae for M-80 powder reputed to be government specified compositions:

ORIGINAL US MILITARY M-80 DIAGRAM



A Word of Caution

Cherry Bombs are small salutes (exploding fireworks) originally known as "Globe Flash Salutes" (U.S. Patent #1,783,999). The Cherry Bomb was made by filling a small paper cup set (similar to end plugs) with Flash Powder, tumbling a number of these in a bowl or drum and coating them with alternating layers of sawdust and a hard-setting adhesive (Sodium Silicate).
M-80s were invented by the military long ago to simulate grenade explosions during training missions. Soon they became extremely popular with the public, and were sold along with fireworks everywhere. But the **Child Protection Act** of 1966 made **M-80s and Cherry Bombs illegal in the United States**. A false assumption people make is that M-80s have some relation to dynamite; as the terms "quarter- stick" or "M-80 half-stick" are widely used to describe the power of such explosives. The compositions used in M-80s and cherry bombs are completely different than those used in dynamite, and the two can't even be compared. Unlike fireworks, which must adhere to strict safety guidelines (like the amount of pyrotechnic composition they can contain), M-80s and Cherry Bombs are ***NOT*** manufactured with your safety in mind. Consumer fireworks, by law, can

contain no more than 2 "grains" (about 130 milligrams) of a specific pyrotechnic composition. Firecrackers can contain no more than 50 milligrams of flash powder per cracker. On the other hand, M-80s contain up to 45 grains of flash powder (nearly 3 grams!). These devices are powerful enough to blow a hole the size of a fist in 3/4 plywood - even if it's only sitting on top of the wood. Though M-80s, Cherry Bombs, and Silver Salutes are now illegal in the U.S., Consumer Firework manufacturers continue to name their products things such as "M-80 Firecrackers", "M-8000s", etc., in an attempt to lure buyers into thinking the fireworks have some connection to real M-80s. But they don't. They're just regular, legal consumer fireworks that have the same powder limits as other fireworks, and are named just to sound "exciting"...or something. They're not even close to being as powerful as real M-80s.

Flash Powder is the Explosive Mix in Firecrackers Today. In the past much larger quantities of Flash Powder was used in Cherry Bombs (Rolled saw dust and Sodium Silicate - Water Glass around a bag of Flash Powder), M-80s and Ash Cans.

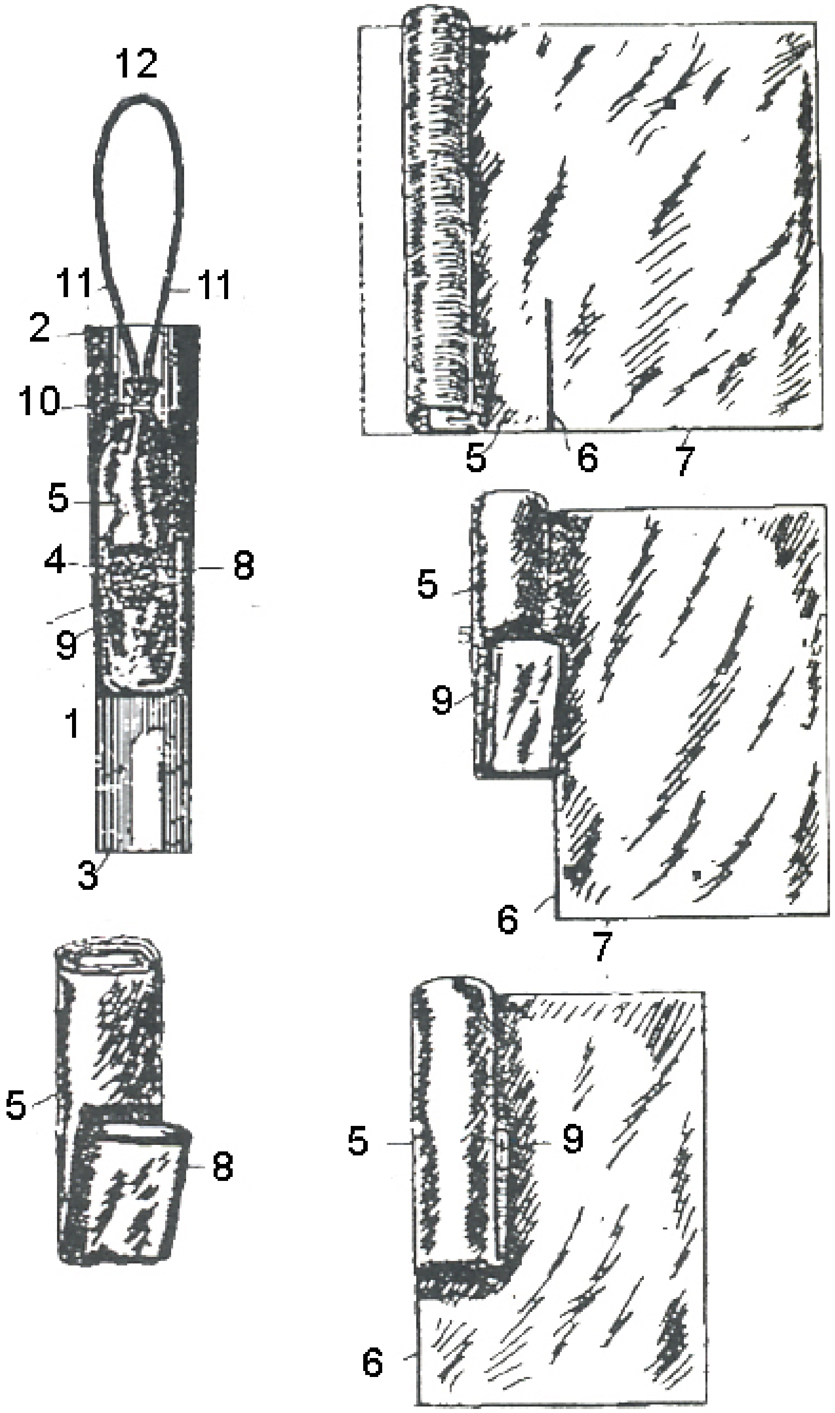
WARNINGS

If using a Glue Guns, use a Low Temperature one. Clay or Sodium Silicate is better than Hot Melt or Elmers/Lepage white glue because it disintegrates. Glues tend to make projectiles. Potassium chlorate can detonate on impact, Potassium Perchlorate is safer. Remember: M-80s, Silver Salutes, Ashcans and Cherry Bombs produce a fireball about a Yard in diameter and can blow a hole in ¾" plywood. Human Injury can be devastating – BE CAREFULL

The Hitt Flashcracka consists of a paper tube containing an inner paper flash bag. This bag is made of a thin kraft paper rolled into a tube as shown. When partially inserted into the outer tube, the bag is filled with flash mix, a fuse is added, and the bag is tied shut. The bag is then pushed into the center of the outer tube and glued in place.

1. Paper body tube
2. Opening in top of body tube
3. Opening in bottom of tube
4. Flash powder
5. Paper Hash hag
6. Cut made in paper for forming closure flaps of flash bag
7. Outer wrap of paper for flash bag
8. Outer bottom flap of paper flash bag
9. Inner paper flap closure of flash bag
10. Neck of flash bag tied off with string
11. Safety fuse
12. Loop of safety fuse (assures ignition of two fuses for decreased risk of ignition failure)

T.G. Hitt Flashcracka Diagram



Preparation Firecrackers: Roll Kraft paper on 1/8" dowel to achieve no more than 1/16" wall thickness, (glue only starting turn and finishing turn) use one of the Flash Powder compositions below, commercial firecrackers use 50 milligrams of Flash Powder, see illustration.

Preparation M-80:

1 - Tubes from Fax Machine Used Paper Rolls are Great for M-80s (2" - 2 ¼" long, 3/16" dia., inside wall. (or purchase off of ebay, type in "Pyrotechnics Fireworks Tubes or use and Online Link at the end of the e-Book") Drill hole in center of tube, insert green fuse, allow 2 ½ wick, glue (Elmer's) end with cardboard fashioned cap allowing 1/8" to fill with Sodium Silicate, FILL with one of the Flash Powder compositions below, glue cap other end and do the same, filling with Sodium Silicate.

2- Roll Kraft paper (can use paper grocery bags) on ½" dowel to achieve no more than 1/16" – 3/16" wall thickness, (glue only starting turn and finishing turn) use one of the Flash Powder compositions.

Preparation "Surefire" M-80: Same as above but fill Flash Powder composition to within 1/16" of wick, cover wick with 4FFF Black Powder, then fill remainder with Flash Powder composition. This version will work with 400 mesh aluminum and any fuse even waterproof that sometimes causes a "DUD".

Preparation "Loudest" M-800 (Discovered by Accident) Same as above but includes a cut-off firecracker (exposing flash composition) with the longer green fuse (There's always one in a cracker pack). Drill a hole in the center of the tube and glue the cut firecracker to ½ the depth. Glue around the firecracker. Fill the Tube. Somehow the rapid discharge of the cracker ignites the flash faster, the insert of the foreign firecracker causes a 5 times louder report. This was done to Dud M-80s.

Preparation Cherry Bomb: Mix the original composition or one of the flash compositions below into a plastic bag or two half kraft paper fashioned cups creating a ¾" ball. Dip in Sodium Silicate and add Saw dust (dyed red). Repeat process until Wall should is less than ¼". Drill and insert visco fuse.

Preparation Cherry Bomb X2:
(This is a very Big Cherry Bomb)

For this project, you must obtain the following: a package of ping pong balls; waterglass (sodium silicate) Visco fuse or similar; Hot glue and a hot glue gun; Sawdust or wood meal; a report composition or Flash Powder.

First, sand the ping pong ball lightly with rough grit sandpaper until it has acquired a rough surface. Then, drill a 1/8th" hole (yes, drill, poking splits the ping pong ball) into the ping pong ball. Funnel all of the report composition you can into the ping pong ball via this hole (using a thin copper wire to help the flow of the report comp helps here). Then, insert a length of Visco into the hole and seal around the Visco with hot glue (wiping the excess off with your finger, thereby making a smooth seal).

You can dissolve red dye in some warm water and add the solution to the sawdust, and allow it to dry. The sawdust would have a nice cherry red color. Then, mix some of the dry sawdust in with your water glass solution until it is colored a nice cherry red and has about the consistency of oatmeal. Dip the ping pong ball (but not the fuse!) into this water glass/sawdust slurry, and allow the water glass to harden well. Then, apply a thin final coat of water glass/sawdust slurry with a paintbrush, and then dust some red sawdust evenly over the ping pong ball (it will adhere to the final water glass/sawdust slurry coating), and allow the water glass to cure for two days before using.

Preparation American Cannon Crackers:

Flash Powder Composition #1

(Industry Standard)

Potassium perchlorate...70

Aluminum Powder……………………30
(3 or 5 micron size)

Sodium Silicate (Water Glass)………Sealent

Flash Powder Composition #2

Potassium perchlorate...50

Aluminum Powder ……………………………………..25
(3 or 5 micron size)

Sulfur…………………………………………25

Sodium Silicate (Water Glass)………Sealent

Flash Powder Composition #3

Potassium chlorate…………………………………30

Aluminum Powder ……………………………………..40 *(3 or 5 micron size)*
(3 or 5 micron size)

Sulfur…………………………………………30

Sodium Silicate (Water Glass)………Sealant

Flash Powder Composition #4

Potassium perchlorate	50
Antimony sulphide	33
Magnesium	17
Sodium Silicate (Water Glass)	Sealant

Flash Powder Composition #5

Potassium Nitrate	50
Magnesium Powder	50

Flash Powder Composition #6

Barium Nitrate	68
German Aluminum Powder	23
Sulfur	9

Flash Powder Composition #7

(Original US GOVERNMENT M-80 Composition)

Potassium perchlorate	66
Aluminum Powder	17
Sulfur	17

Flash Powder Composition #8

(Original US GOVERNMENT M-80 Composition)

Potassium perchlorate	64
Aluminum Powder	22.5
Sulfur	10

Antimony sulfide…………………………….9

Flash Powder Composition #9

(Original US GOVERNMENT M-80 Composition)

Potassium perchlorate……………………………………67

Aluminum Powder ……………………………………………………………17

Sulfur………………………………………………………………….8.5

Antimony sulfide…………………………….8.5

Flash Powder Composition #10

Potassium perchlorate……………………………………………..64

Aluminum Powder ………………………….27

Antimony sulfide……………………………………….9

Flash Powder Composition #11

Potassium perchlorate…………………………………29

Potassium chlorate……………………………………………………27

Aluminum Powder ………………………….22

Antimony sulfide……………………………………….15

Sulfur………………………………………………………. …………………………….7

Flash Powder Composition #12

(Thomas Hitt’s “Flashcracka”)

Potassium chlorate	49
Aluminum Powder	42
Sulfur	9

Green Flash Powder Composition #13

Strontium Nitrate	50
Magnesium Powder	50

Red Flash Powder Composition #14

Barium Nitrate	50
Magnesium Powder	50

American Cannon Cracker Composition #1

Potassium chlorate	57
Antimony sulfide	29
Charcoal	14

American Cannon Cracker Composition #2

Potassium perchlorate	40
Antimony sulfide	20
Charcoal	20
Sulfur	20

American Cannon Cracker Composition #3

Potassium perchlorate	57
Antimony sulfide	29
Rosin	14

American Cannon Cracker Composition #4

Potassium perchlorate	50
Charcoal	25
Red Gum (Accroides)	25

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3 Projects (Fountain, Roman Candle, Pinwheel)

BASIC LAWN FOUNTAIN

Materials required: Kraft paper or Grocery bag paper 6 inches wide by 36 inches long. A 3/4 inch dowel, 4 inches in length. Fire clay or air hardening Modeler's clay.

Begin construction by wrapping the end of the Paper around the dowel (**figure 1**). Roll a couple turns of paper around to hold it in place. Don't get any paste on the dowel, and take care not to wrap the paper so tightly that the dowel can't be withdrawn.

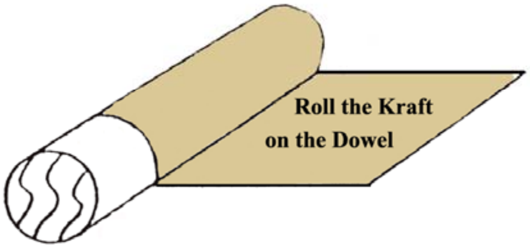
Next, apply wallpaper past or to the entire remaining surface of the paper and roll into a tight cylinder. Be careful to smooth out any lumps in the paste before rolling. When the dowel is removed, a strong paper tube approximately 1 inch in diameter remains (**figure 2**). The casings for rockets, roman Candles, etc. are made in the same manner and are said to be "wet rolled," the entire surface of the paper being pasted. When only the last inch or so of a paper cylinder is pasted, it is said to be "dry rolled." Dry rolled tubes are suitable for simple colored fire compositions.

Apply glue to 1 inch of the inside of the cylinder and slide the dowel back into the cylinder 1 inch (**figure 3**). After drying, sharpen the dowel to a blunt point.

The next step is to fill the cylinder with a fountain composition (Chapter 2). Bore a 3/4 inch hole through a board. Push the dowel end through the board and stand upright (figure 4). Add small amounts of dampened fountain composition at a time, tamping down each portion with a dowel and mallet. Each small portion should be dampened separately as it dries quickly. **DO NOT** ram dry mixtures with the mallet. The mixture must be kept damp at all times or an explosion could result. After the cylinder is filled to within 3/4 inch of the top, a small wad of dampened fire clay is pressed on top leaving about 1/8 inch of empty cylinder. This paper "lip" is crimped down over the clay to hold it in place.

Allow the clay and fountain composition to dry for a couple of days. Force drying in an oven is possible, but **not to exceed** 150°. After everything is totally dry, drill a hole down through the clay and composition to a depth of 2-1/2 inches with a 1/4" drill (**figure 5**). Place a fuse in the cavity and secure with a wad of tissue. This device will produce a fountain about 20 feet high, somewhat in the shape of a tree.

Figure 1



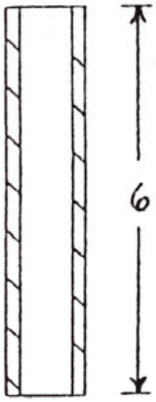


Figure 2

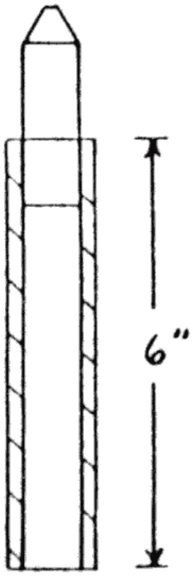


Figure 3

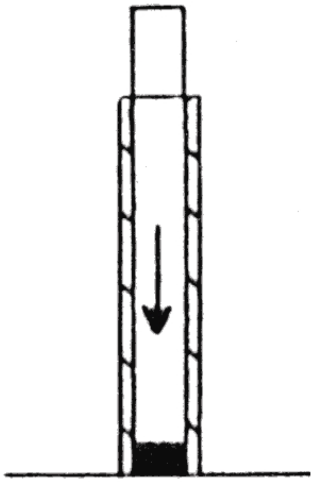
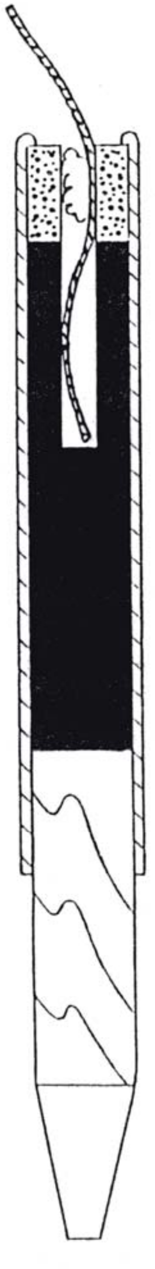


Figure 4

Figure 5



BASIC ROMAN CANDLE

Roman candles are strong paper cylinders from which flaming masses of material called stars are launched in successive bursts. They are placed upright in the ground by means of a sharpened stake at one end.

Materials required: Kraft paper, 12 inches x 36 inches long. A 3/4 inch dowel, 5 inches long.

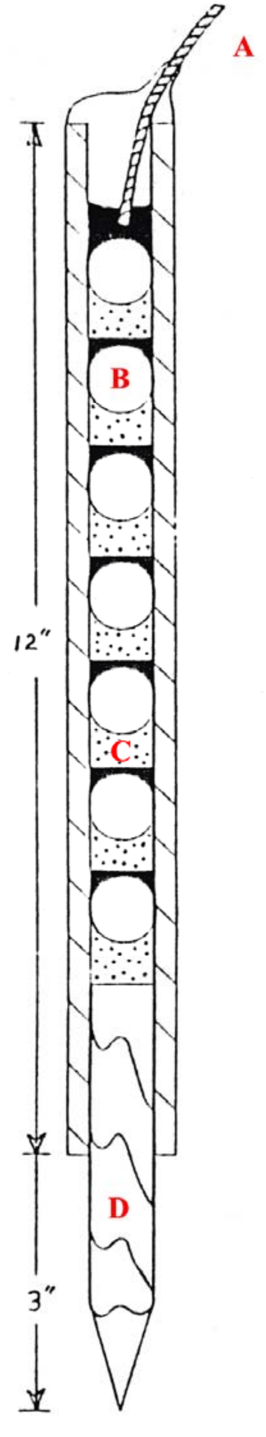
Wet roll a cylinder as with the lawn fountain. Apply a strong glue to 2 inches of the inside of the cylinder and slide the 5 inch dowel back into the cylinder a distance of 2 inches. After drying, sharpen the dowel to a blunt point. Take a small amount (marble sized) of star composition and roll on a hard flat surface with your palm until spherical. While the ball is still damp, roll lightly through finely crushed black powder (if the star contains potassium chlorate the powder coating may not be necessary). The fine powder coating aids in ignition. Allow the ball shaped stars to dry thoroughly or force-dry in an oven. They should be just large enough to fit the cylinder with slight pressure. The easiest way to load the a cylinder is to place them upright in a block of wood. First load the tube with 1/2 teaspoon of 3FG black powder. Press a star lightly into the powder with a dowel. Add 1/2 tsp. of candle composition. Add another 1/2 tsp. of black powder, star, candle composition, and so on, for a total of 7 stars. The final charge is dampened candle composition into which a fuse is placed.

CANDLE COMPOSITION:

Potassium nitrate	35 parts
Sulphur	7 parts
Charcoal	21 parts
Dextrin	1 part

Grind all ingredients to a fine powder and mix thoroughly. Moisten the mix slightly and rub through a screen. Dry the grains quickly in a shallow tray. The candle composition acts as a fuse, transmitting the fire between bursts.

BASIC ROMAN CANDLE



A. Fuse

B. Star

C. Black Powder

D. Dowel

PINWHEELS

Small rocket like tubes are attached to the sides of this triangular device. The tubes shoot out jets of fire, causing the device to rotate about the central hole through which it is fastened to a pole or building with a nail.

Cut out an equilateral triangle 4 inches on a side from stiff cardboard. Locate the exact center and drill a 3/16 inch hole. Cut off the sharp comers as shown. Wet roll 3 cylinders of 1/2 inch outside diameter and 5/16 inch inside diameter. Kraft paper packaging tape is ideal as it's already gummed. Clay nozzles are made as for the rocket, but need not be as precise. A pencil point will do for a spindle.

Load the #1 cylinder with the following:

Black Powder	2.0 parts
Potassium nitrate	1.5 parts
Charcoal	1.5 parts
Steel filings	1.0 parts

[Dampen and tamp into cylinder]

A piece of quickmatch leads to cylinder #2 which is "press loaded" with the following:

Potassium perchlorate	70%
Sodium benzoate	30 %

[Percentages are by weight]

Load cylinder #3 with:

Meal powder	8 parts
Potassium nitrate	14 parts
Steel filings	6 parts
Sulphur	4 parts
Lampblack	3 parts

Cylinder #1 will produce a steel effect of scintillating sparks.
Cylinder #2 gives a yellow circle accompanied by a loud whistle.
Cylinder #3 throws out showers of spur shaped sparks. Be sure

to tamp mixtures into the cylinders in small increments. Some other pinwheel effects are as follows:

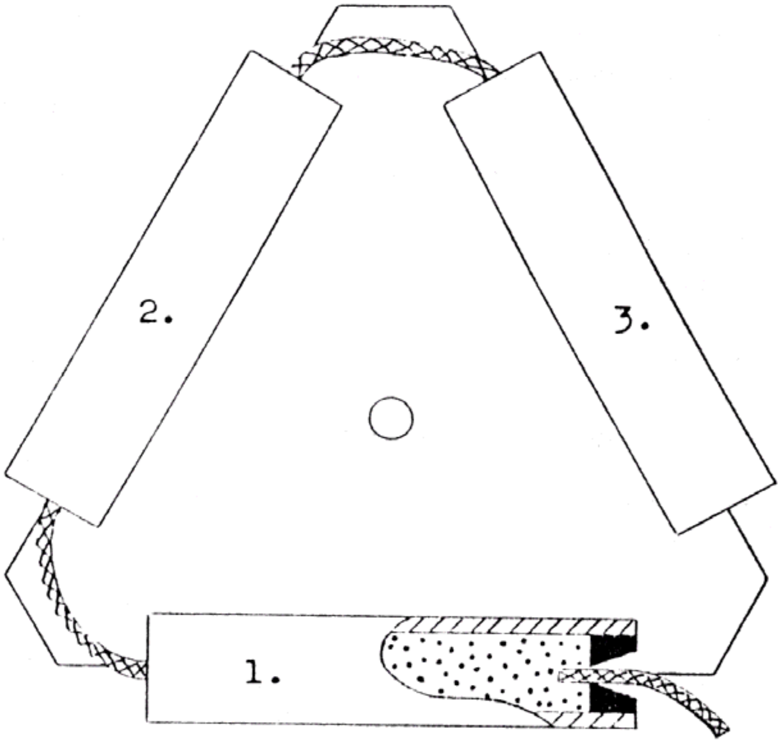
ALUMINUM

Black powder	16 parts
Potassium nitrate	16 parts
Aluminum	3 parts
Sulphur	3 parts

LILAC CIRCLE

Black Powder	2 parts
Potassium nitrate	2 parts
Sulphur	1 part

.


2.
3.
1.

14

Fuse

BLACK MATCH:

FFFFg Black Powder………………………20

Dextrin ……………………………………………1

To make dextrin, spread an entire box of corn starch out on a cookie sheet and cook it in the oven at 400° for about 2 hours, stirring it every 20 minutes or so with a spatula to keep it from burning. When it's done, it will be light yellow/gold in color.

100% cotton cord (Butchers Cord) 1/8" or 1/16"

Hot Water

Begin adding hot water while blending the mixture until it has about the same consistency as tomato soup. Soak cord in solution. Next, take a piece of sheet metal, lexan, Plexiglas, or other non-absorbent material and drill a 1/8th" or 1/16" hole through it. This will be the die used to control the overall diameter of the fuse. Put one end of the BP-paste-coated string through the hole and pull until the entire string has passed through the hole. This will take off any excess BP paste and ensure that the Black Match is 1/8th" OR 1/16"in diameter. Now, stretch between 2 nails.

BLACK MATCH 2:

FFFFg Black Powder………………………20

Shellac…………………………………………………Coat

Charcoal……………………………Add

100% cotton cord (Butchers Cord)

Hot water

Begin adding hot water while blending the mixture until it has about the same consistency as tomato soup. Soak cord in solution and stretch between 2 nails. Add Charcoal to decrease burn time. Coat with Shellac to water proof.

QUICK MATCH:

Quick match is a special type of fuse that can burn at up to 100 feet per second. Quick match is simply black match that has been covered with a loose-fitting paper tube (known as pipe). When regular fuse burns, the hot gas produced by the flame is simply released into the air. When the fuse is put in a paper tube, however, the hot gases can not escape, so they simply shoot along the length of tube at incredible speeds.

Black match fuse
Kraft paper
Low temp glue gun and glue sticks
Scissors or sharp knife
5/16 inch dowel rod, 20-24 inches long

Begin by making the paper tubing the match will go in. Cut off 2-3 foot lengths of Kraft paper, and then cut each of these into strips 1½ inches wide by the length of the roll. Trim these down so they are only 15'' long. Most Kraft paper rolls are 30 inches long, so you can just cut the pieces in half. Low temperature glue guns can be bought at any craft store for just a couple dollars. The reason to use low temp is because it won't hurt your fingers when you touch it.

When you have several strips, roll each strip around the dowel lengthwise to form a long tube. Glue down the overlapping edge in the middle, on the ends, and in between. You should now have a paper tube being held together in a few places. Squirt some of the glue underneath the portions of the edges that haven't been glued, and press them down. It's ok if some of the glue oozes out; it shouldn't hurt your fingers. Now run a line of glue down the seam of where the paper is glued to itself, and smear it around with the metal nozzle of the gun. This helps insure an air tight seal so the gases won't leak out. Let it all dry for about 10 seconds, then remove the dowel and proceed to making the next tube.

Once you have several tubes, you can begin piping the black match through it Lay your black match on a clean surface such as a driveway or sidewalk. Thread it through the tubes until the tubes come to the end of the black match. The rigid ness of the fuse should make it easy to thread through the tubes, but if not, tape the end to something long and narrow like a shish kabob skewer and thread it through the tubes like a needle.

Now you need to make all of the tubes into one continuous tube. Start at the joint between the first two tubes. Cut a 1" slit in one of the tubes (so it can fit inside of the other), put a little glue around it, and push it into the neighboring tube. As you did when making the tubes, put a bead of glue around the joint and smear it around with the gun's nozzle. Do this with all of the joints until the piping is finished. When it's done, your quick match is ready for use.

QUICK MATCH PIPING:

There are several ways to make match pipe, but I personally favor the following method for making spiral-wound pipe of fixed lengths. It is very easy to master, and the average individual pyro enthusiast can easily make an entire year's worth of match pipe in a single morning.

Supplies needed: smooth metal rods of desired length (I use 1/4" x 3 ft. and 1/4" x 4 ft. steel rods from Home Depot); 6" wide masking paper (very thin kraft with a shiny (waxy?) backing found in the paint section at Home Depot); foam brush (3/4" or 1" wide, usually gray foam and wooden stick, also in the paint section at Home Depot); damp sponge; paper towel; spray oil (I have used everything from non-stick cooking oil to WD-40); holder for paper (a piece of 3/4" plywood with a 4" length of 1" dowel rod and a heavy brick works well); large flat, smooth surface; glue or paste (I prefer carpenter's glue diluted 1:1 with water).

Step 1. Cut the roll of masking paper into thirds (i.e., 2" wide rolls) using a band saw with a sharp blade. This is easiest to do if you first draw a circle around the roll using a paper band as your guide. Also make sure that the paper cannot unravel during cutting (i.e., tape down the edge).

Step 2. Because I cannot easily provide a figure, I will describe the ideal arrangement of equipment by making reference to a right triangle. Place your metal rod on your work surface so that it is positioned lengthwise from your left to your right. This is one side of your triangle and it defines two points. Your paper holder defines the third point, and it should be placed so that the angle on the left side of your triangle is approximately 20 degrees and the angle on the right is 90 degrees. (In practice, you will want to move your paper holder slightly further back and to the right, but you should get the picture.)

Step 3. Pull a piece of paper from the holder and rest it along the end of your triangle (this is the hypotenuse of your triangle). Cut or tear the paper from the roll and make sure the shiny side of the paper is facing up.

Step 4. Apply a VERY SMALL amount of glue along the far edge of your paper using the foam brush. Do not apply glue to the first 3" on the left side and don't use too much. You don't want the paper to get wet. You only want a thin (1/4" wide) band of dampness due to the glue.

Step 5. Place your rod on the lower left-hand edge of the paper. Then move the right hand edge approximately half way from its original position toward the paper holder. This positions the bar at a 10-degree angle relative to its starting position. Now roll the bar away from you. Use your hands to guide the paper to be sure the match pipe rolls up smoothly. If all goes well and your rolling technique is similar to mine, the bar will rotate slightly clockwise and end up parallel to your working surface. (This is why you start 10 degrees counterclockwise.)

Step 6. If you have done everything properly, you should be able to slide the match pipe off your metal rod. Allow your pipes to dry for about 15-30 minutes, then trim the ends with a pair of scissors.

Helpful hints and other comments.

1. I have made match pipes up to 6 feet with this procedure, but 3 or 4 feet pipes are easiest to make. I have also made match pipe on a 1/8 “aluminum rod with 1” wide papers.

2. Use a longer piece of paper so that the pipe extends beyond the rod. Then twist the end closed. This prevents the damp pipe from unraveling, and the excess is a convenient place to grab while pulling the pipe off the rod.

3. Work quickly after you apply the glue. You don't want things to get soggy or have your glue dry.

4. If your match pipe sticks, you probably used too much glue. Give up on a soggy pipe. Unravel it or scrape it off quickly. (The longer you wait, the harder it is to remove.) Wipe the rod clean with a damp sponge, dry it with a towel, and then apply a very thin layer of oil by wiping with an oil-dampened towel.

5. Some people don't like spiral match pipes because they cannot be easily torn to expose match. To be quite honest, I actually like the fact that my match pipe is hard to tear. If you use spiral match pipe made by this method, two things will make your life easier. First, a little planning to make sure you have the proper amount of match exposed when you assemble your device in the first place. Second, carry a penknife.

6. It can be difficult to slide match into spiral match pipes if it has irregular edges which can get caught on the inside or if you have kinks in your pipe (i.e., you bent it at some point). Store your match pipes in a long tube and avoid kinking. I can describe an easy way to make smooth match, as well as an efficient way to insert match into these preformed tubes, but that will have to wait for another day. FJF

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Equipment Used In Pyrotechnics

Balance Scale:

This is a must due to the fact that to make pyrotechnic devices you need to measure your compounds. The triple beam laboratory scale is the best for pyrotechnic purposes. Powder balances like that used by people who reload their shotgun shells also works well. Also, a student-grade lab balance works well and is simple and reliable. Electronic balances are good but expensive. The worst balance you can use is a spring scale.

Blender:

Normal kitchen blender is fine. Coffee grinder also works. You must be sure to clean the blender after every use. Failure to do so could contaminate other compounds and/or create an explosion from the wrong compounds being mixed. Also, NEVER MIX DRY COMPOUNDS! The static in the air and the possibility of sparks from the motor can lead to ignition.

Corks:

The nature corks made from cork tree bark work great for end plugs and such. The newer synthetic types made from rubber or plastic are not good to use since they are hard and become lethal when they are projectiles.

Fuse:

The best to use is visco safety fuse. It is green in color. This fuse has a black powder center, around the powder is a paper and threat and then it is coated with nitrocellulose lacquer. Another type of fuse that is used specifically for aerial bombs and shells is called time fuse. This fuse is dangerous in the aspect that it burns internally, you cannot tell if it’s been lit or how far it’s burned. The safety fuse you can clearly see when it’s lit and where it’s burning at. Never skimp on the fuse! Use as much as possible.

Fuse Cutter:

These are just devices used to cut fuse quickly, safely, and easily.

Gloves:

Latex or other disposable gloves are best to be used when working with irritating or toxic chemicals. Heavy gloves are useful when lighting fireworks since they provide protection. Also, leather gloves are good because they provide protection and free movements in hand.

Glues and Adhesives:

Poly Vinyl Acetate (PVA) Also known as "white glue", much like Elmer's, works well for many applications but is expensive. This glue is not good for gluing time fuses into place as it has been known to penetrate the fuse core and damage it.

Hide Glue This comes in liquid and solid forms for heat application. Works well for some applications needing animal glue. Not too much more to say.

Epoxy Resin Glues Great for applications requiring great strength such as gluing the base onto a mortar tube.

Hot-melt Glue is popular for certain applications. Caution must be exercised when using this due to the fact it is dispensed from an electrical appliance. Electrical hazards and heat hazards are present.

Jigs:

Jigs are useful tools for holding tubes or devices while filling them. Jigs can be made by drilling holes in a board using a drill press. Each hole is sized to fit a particular diameter tube.

Paintbrushes:

Large brushes are good for applying glue. The smaller brushes are good for mixing and combining chemicals, but be sure that it is natural fibers (synthetic causes static). Also its important to type over and exposed metal on the brushes, sparks can occur. After use, brushes should be cleaned with Ivory soap (real soap). This helps get excess chemicals off the brush and gives the bristles a static-inhibiting coating. Detergents can create more of a static hazard if used.

Paper:

The best paper for pyrotechnics is Kraft paper. This is the paper used for grocery bags. It's brown and comes in many thicknesses. Grocery bags are medium thickness and that's the best to use if you're making tubes or such. Thin (like the small lunch bags) is good for flash bags in Firecrackers. Gummed Kraft paper is very useful since it already has an adhesive on it and can be found in precut sizes that suit a pyro's needs. Tissue paper is good for decorating your tubes if you have too much time on your hands. It is also good for making parachutes but a Chinese paper called Ganpi/Gampi is stronger both dry and wet.

Powder Scoops:

There are many powder scoops available out there. Sets can be found containing most of what you would need for a cheap price.

Presses:

Presses are really only useful if you plan on making whistling devices or rockets. Hydraulic and pneumatic presses are probably the best to use. The benefits of using a press are that consistent pressure is applied, unlike when you use a rammer. Also, there are fewer hazards from shock than if you'd be using a rammer.

Respirator:

This is a must when working with toxic chemicals and meal powders. It is unwise to use those cheap disposable masks. Buy the real models, such as Bink's respirator w/ replaceable filters. You're basically paying an amount for your health, don't get cheap.

Rock Tumbler:

This is useful for certain applications. Mixing chemicals or grinding chemicals can easily be accomplished using an average rock tumbler. By adding a medium, such as brass balls or ceramic grinding balls, you can crush to a fine powder most chemicals.

Sieves:

These are important for mixing some compositions. Sieves are measured by their mesh size which is simply the (but not exactly) the number of openings in a square inch. The best size for pyrotechnic powders is probably 20-40 mesh. It is important to use brass or lead, a non-sparking material.

String:

Certain designs call for string. Quality cotton or cotton/polyester will work fine

16

Glossary

Pyrotechnic Chemicals

OXIDIZING AGENTS:

Potassium Nitrate better known as saltpeter. It can be found in granulated and powder forms, both white in color. Saltpeter is the main ingredient in black powder and the most important chemical in fireworks. It is not poisonous enough to cause concern when working with it. It is known to irritate the mucous membranes though. It is soluble in water but not hygroscopic (hygroscopic-absorbs water from the air). Be careful not to spill any on organic materials, the nitrate will cause the organic materials to be much more flammable.

Sodium Nitrate This chemical contains more oxygen than the potassium nitrate but is highly hygroscopic and because of this, rarely used. This chemical is cheaper than saltpeter so when large amounts of oxidizers are needed, this is used. Only the powder form is useable for pyrotechnics and it must be used within a few days due to its hygroscopic qualities. The same safety precautions as saltpeter should be exercised.

Ammonium Nitrate This is used usually when a smokeless powder is desired. This chemical is hygroscopic and should be used within one month of purchase. Only the powdered form is usable for pyrotechnics.

REDUCING AGENTS:

Charcoal The most common reducing agent. It is familiar to everyone since it is commonly used in backyard barbeques. Only softwood charcoal should be purchased, hardwood doesn't burn as well and should never be used. The purest charcoals are pyrotechnic grades and should be used if possible. Also, charcoal with a brownish tint should not be used. Charcoal is available in dust, coarse, and mixed varieties. There are no safety hazards.

Lampblack This is a different from of charcoal which is produced by burning coal rather than wood. The best grades should be bought, oil impurities will affect the brilliant effects of pyrotechnics.

There are no safety hazards.

Shellac This is not the common liquid shellac found in paint stores. This shellac is fine powder from an insect common in India. Shellac is one of the best carbon sources and is also a reducing agent. It is second to picric acid in producing a rich color and equal to red gum in its reducing properties. Shellac is expensive and only used when top quality is an issue. Only the TN grade is suitable for pyrotechnics.

Stearic Acid This helps to produce a richer blue flame than is available to any other reducing agent. Only the finest powder should be used. There are no safety hazards.

VAPORIZING AGENTS:

Potassium Chlorate NEVER EXPERIMENT WITH THIS CHEMICAL! IT SHOULD ONLY BE USED IN KNOWN FORMULAS AND MIXTURES. Spontaneous inflammation can occur if mixed with sulfur, sulfides, picric acid, etc. Mixture's containing potassium chlorate must be used within a few weeks, as it gets unstable and sensitive. Be sure to dispose of it properly. This chemical is white in color and should be in a very fine form for pyrotechnics. It should contain no more than 1% sodium, calcium, and magnesium salts combined. Handling precautions are the same as with saltpeter. Never inhale or ingest potassium chlorate as it is slightly poisonous. If 1/10 of 1% sodium bicarbonate is added to potassium chlorate, it will help to neutralize any free acids in the chemicals to be mixed with the potassium chlorate.

Potassium Perchlorate This chemical is much safer than potassium chlorate as this chemical is salt. Also, perchloric acid is much more stable than chloric acid, which is where the potassium salt is derived. Generally this is white in color (pink may be found). It can be mixed with sulfur. Potassium perchlorate should be obtained in a fine powdered form. It IS toxic and can irritate the mucous membranes if inhaled. External contact with skin is not harmful. Unfortunately this is not suitable for caps or torpedoes.

Sulfur The most popular vaporizing agent due to the fact it lowers ignition temperature for most pyrotechnic mixtures. Flour of sulfur (finely powdered) should be obtained. Flowers of sulfur are completely different and shouldn't be confused with flour of sulfur. It is better to have in a form that is low in acid content. Non-toxic and no special precautions necessary. Also, new batches of this should be tested for acidity, high acid levels can be dangerous in some applications.

Calomel The chemical name for this is mercurous chloride, not to be confused with mercuric chloride which is a potent poison. This chemical is used to brighten the colors of dull mixes. It is very expensive but only a little amount is need for compositions.

Picric Acid This is an explosive more potent than TNT, but is used to deepen the colors of pale spectra imparters. It is also used in whistling pyrotechnics. It is sold in a wet form to reduce accidental explosions. Dry picric acid is of high risk to that. Picric acid should be handled with care. It should never come in contact with skin (it will leave a yellow acid stain). It should never come in contact with metal (it will turn to metal picric and becomes unstable and could instantly explode.

SPECTRA IMPARTERS:

Barium Chlorate This chemical produces a rich green color, it is more expensive then barium nitrate but produces a far better color. This chemical is unstable when combined with certain other chemicals. The reason for this is that it is a salt of chloric acid (as is potassium chlorate). Handling precautions are the same as with potassium chlorate. All barium compounds are extremely poisonous and gloves must be worn when handling it, also a respirator should be used.

Barium Nitrate This is inexpensive but produces a pale green (unless mixed with calomel). A powdered grade should be used. It does not absorb water from the air but is know to cake at times. It is extremely poisonous and the same safety precautions should be used as you would barium chlorate. This chemical is also sometimes used as a substitute for potassium perchlorate in flash mixtures.

Sodium Oxalate Cheap, safe, and produces a great yellow color which is better than most sodium compounds. Inhalation is not poisonous but can produce ill effects.

Paris Green The chemical name for this is copper acetoarsenite. It is a poisonous salt of arsenic. This chemical is used to make the color blue. A fine powder is the best to use (can be purchased at paint/insecticide dealers). Never allow this chemical to come in contact with skin. Contaminated areas of skin should be flushed with water for 15 minutes. If inhaled or ingested, induce vomiting and then take a does of 3 tablespoons of tannic acid in a glass of warm water (white of an egg can be substituted for tannic acid). Call your physician.

Red Arsenic This mineral is used to make white fire and smokes. It is very poisonous and the same precautions as paris green should be followed.

OTHER COMPOUNDS:

Magnesium Powdered magnesium produces a blinding flash when ignited. Magnesium is expensive (compared to aluminum) but safer to use in certain combos. Powdered and 100 mesh is suitable for pyrotechnics.

Aluminum This used to produce flashes, flares, tails of comets and more. Aluminum is not affected by water. Combinations of potassium chlorate and aluminum are dangerous. The aluminum should be 95% pure and be a grade marked CP. If spilled, it can never completely be removed from any surface. Aluminum should not be inhaled as it is damaging to the lungs, also it has been researched to be a causer of Alzheimer's disease.

Alcohol Ethyl alcohol is used for making fulminates. It should be 95% alcohol by volume and less than 5% water. Pyridine and methanol are the only acceptable denaturants. Denaturants are poisonous. Alcohol is flammable.

Dextrin This is used as glue to bind chemicals on sparklers or stars. When mixed with water it becomes gummy. It is inexpensive and should be purchased in the yellow powdered form. No special safety precautions.

Black Powder Never use modern smokeless powders in pyrotechnics, only black powder or the Blasting B powder. BP is usually used for driving shells and blackmatch/fuses. This should be kept in a tightly sealed container. Older powder when stored under conditions (like excessive heat, cold,...) is unstable and a mild blow can detonate it.

Lactose This is used in some of the smokes in this site. This and sucrose are harmless sugars available at most drug stores. It should be obtained in fine powdered format. Glucose can be used as a substitute if necessary.

Meal Powder This is not ground meal used in cooking, this consists of 15 parts saltpeter, 3 parts charcoal dust, and 2 parts sulfur (by weight). This requires the same safety precautions as any black powder.

Red Phosphorous This is the most dangerous chemical that will be needed for certain formulas in this site. It is extremely sensitive. It should never be mixed with potassium chlorate unless both have been wet before the mixing. The chemicals CAN explode if they are just pushed together. This chemical is used for caps and scratch mixes and will ignite if a match is touched to it. When burned, a dense white smoke is produced which is harmful to the mucous membranes.

Steel Filings This produces eye catching effects such as tails and sparks. Rusted steel will not work so these filings must be coated with melted paraffin. The steel needles are best for pyrotechnics.

Ammonium Picrate This is difficult to obtain but can be made by adding strong ammonia water to a boiling solution of concentrated picric acid contained in a glass container. Never use a metal container (explosion may result). Filter out the red crystals after the mixture has cooled. Ammonium Picrate is used in whistling compositions and colored fires (smokeless). The same precautions as with picric acid should be followed for this chemical.

Naphthalene Available in hardware stores as moth balls. Purest forms are preferred and then should be grinded into a powder. This is used in smokes due to its high ash content.

Hexachloroethane Difficult to obtain, used in smokes, and no special precautions.

Zinc Dust Used as rocket fuel. Sometimes in spreader stars. Mixing instructions must be followed to the letter, unexplainable accidents are possible.

Mercury & Silver Metals Pure grades of these metals are used to make fulminate salts which are used to make fulminates for pyrotechnics. These are highly explosive. Small amounts of metal are needed for the fulminates and these fulminates should be used immediately after they are made. They should not be stored in quantity.

Mercury & Silver Fulminates High explosives mean they require a permit to buy them. They can be made in a home laboratory. Extreme caution needs to be used when preparing and storing them. Storage should not exceed 5 grams or 2 weeks time. They should be stored in a bottle equaling 20% of their weight. Both are highly poisonous.

Nitric Acid This is required when preparing either mercury or silver fulminates. The two grades required are specific gravity 1.42 and 95% nitric acid. Extreme caution should be used with either of these. Inhaling the fumes will cause permanent damage to the mucous membranes and sear the skin. It causes a yellow stain to appear on the skin but will fade in time.

Sulfuric Acid This is not directly used in pyrotechnics but is used to prepare certain chemicals. Specific gravity 1.84 and fuming 20% are the two grades used for specific purposes. Each grade should be at least 98% pure. Extreme caution needs to be used to prevent the acid from coming in contact with skin or clothing. If in contact with skin, flush w/ water for 15 minutes. If swallowed, DO NOT INDUCE VOMITING, repeated doses of milk of magnesia or egg white at short intervals should be taken. Then call a doctor.

Trinitrotoluene Also known as TNT. This is rarely used in pyrotechnics but the experiments in chemical reactions that will/is at this site will have experiments which demonstrate the power of this explosive.

Accroids Resin Also known as "red gum," this compound is a nature plant product that is commonly used as a binder and/or fuel in pyrotechnic compositions. Soluble in most alcohols but is not soluble in water.

Antimony In the earlier days of pyrotechnics, this was used as a metallic fuel source since aluminum and magnesium were unavailable. This is hard to come by in the U.S. due to regulations restricting it. It is toxic and protective gear must be worn when handling it.

Antimony Sulfide There are 2 varieties of this, black trisulfide (stibnite or "Chinese needles") and the orange-colored pentasulfide. In fireworks, the tibnite should be of 350 mesh or finer. For additives in flash powder, 200 mesh stibnite should be used. This is a toxic compound. Use caution. Also note that the smoke from antimony sulfide is toxic.

Arsenic Disulfide This is an orange colored salt and is also known as "realgar". It is commonly used in "cracker balls" and certain smoke compositions. The best grade is that from Japan. This is extremely toxic and therefore hard to find in the U.S. Protection is required when working with this compound.

Iron Oxide Common rust that is used tp breakdown chlorates or perchlorates.

Manganese Dioxide Used to catalyze the decomposition of chlorates and perchlorates. Compositions with this compound as well as chlorates or perchlorates are highly sensitive.

Petroleum Jelly Used in some whistling compositions. It seals the water-absorbing crystals and lubricates to allow easy and safe compaction.

Silica Commonly known as Cab-O-Sil or Aero-Sil. This is used in flash powders to strengthen the mixture. This is a fluffy white powder that floats in the air. Hazardous to breath but otherwise non-toxic, non-explosive. Respirator required when working with this.

Sodium Salicylate White crystalline powder used as fuel in some whistling compositions. Highly hydroscopic. 200 mesh particle sizes are ideal for pyrotechnics.

Sodium Silicate Used as a pyrotechnic adhesive. Commercially available in different concentrations. Sold as "water glass" or "egg preserver". 20% but no more than 40% concentration should be used.

Stearin Waxy compound sometimes used as an aid in making meal powder. Also may be used as fuel for certain compositions.

Titanium Best grade is 20-40 mesh for aerial salutes and smaller mesh sizes for use on ground. This is sometimes used to give flash compositions brilliant white sparks. The hot metal sparks are hazardous and this compound's use should be avoided

Literature references

In some cases the original source of the composition is known. In those cases a short references has been made, and the full references are given here.

1. T. Shimizu, "Fireworks: The Art, Science and Technique", Pyrotechnical Publications, Austin, Texas, USA (1981)
2. R. Lancaster, "Fireworks, Principles and Practice", Chemical publishing Co., Inc. New York (1972)
3. "Pyrotechnical", Pyrotechnical publications, Austin, Texas, I(1977)-VI(1980)
4. H. Ellern, "Modern Pyrotechnics", Chemical Publishing Co., Inc. New York (1961)
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6. L.P. Edel, "Mengen en Roeren", 2nd edition (1936)
7. E. L. Palder, "Magic with Chemistry" (1964)
8. Kirk-Othmer "Encyclopedia of Chemical Technology"
9. D. Douwes, "Spelen met Vuur"
10. T.L. Davis, "Chemistry of Powder and Explosives", Wiley, London (1941)
11. J. Lenselink, "Vuurwerk door de eeuwen heen"
12. "The best of AFN III"
13. D. Bleser, "Round Stars and Shells"
14. "The best of AFN II"

Fireworks Clubs

One of the ways you can enjoy fireworks legally is to join a fireworks club. There are dozens of clubs throughout the United States. These clubs provide a legal area to shoot fireworks, and offer opportunities to be able to learn how to shoot fireworks safely. Some clubs even provide a means for members to purchase fireworks at a discount, and to learn how to build and shoot commercial fireworks.

Nearly all of the fireworks clubs in the United States are also endorsed by the Pyrotechnics Guild International (PGI). The PGI provides resources, course materials, written publications, and guidance to clubs and PGI members. In addition, the PGI sponsors an annual convention each year that allows members to get together to exchange ideas and view some of the best fireworks in the world. You should consider joining the PGI if you are not already a member.
Here is a list of the fireworks clubs in the United States:

Connecticut Pyrotechnics Association
http://www.cpapyro.org

For More Info:
* Alfred Rose, (860) 442-1602 arose03@snet.net

* Sean Malley, (860) 669-5674 cpapyro@snet.net

Crackerjacks Fireworks Club
http://www.crackerjacks.org

For More Info:
* Ben Sego, (703) 242-2272 bsego@methodin.com

* Norman Whetzel, (703) 787-8786 nwhetzel@iamdigex.net

MoPyro
http://www.mopyro.com

For More Info:
* Nick Speraneo, (314) 369-1142 nick@mopyro.com

* Lisa Speraneo, (314) 369-1142 lisa@mopyro.com

Michigan Pyrotechnics Art Guild
http://www.mpag.org

For More Info:
* Aaron Enzer, (734) 428-0900 aaron@ace-e.com

New Hampshire Pyrotechnics Association
http://clubs.yahoo.com/clubs/nhpa2

For More Info:
* Dave Pierson, (978) 897-9729 davep@quik.com

Pyrotechnic Artists of Texas (The Texas Fireants)
http://www.fireants.org

For More Info:
* Amber Dover, (972) 335-8222 ladypyro@attbi.com

Rocky Mountain Pyrotechnics Guild
http://www.rmpg.org

For More Info:
* Rob Peacock rob@rmpg.org

Stumptown Shooters
groups.msn.com/StumptownShooters
For More Info:
* Gene Zdrazil, (319) 629-5162 gzdrazil@msn.com

* Scott-Allen Stutzman, (319) 631-0224 sstutzman@w-se.com

Western New York Pyrotechnic Association
www.wnypa.com

For More Info:
* Bob Leo, (585) 826-4921 skyartist@wnypa.com

* Jeff Staskiewicz, (585) 343-9118 stick@iinc.com

Western Pyrotechnic Association
http://wpa.pyrotechnics.org

For More Info:
* Kief Adler kief@pyro.org

* Don Oesterle don@pyro.org

Wisconsin Pyrotechnic Arts Guild
http://www.tznet.com/shubing/wpag

For More Info:
* Steve Hubing, (715) 238-7712 shubing@tznet.com

* Jerry Worrick, (920) 743-5827 fireworks@dcwis.com

INTERNET SOURCES

http://www.firefox-fx.com/

http://www.cannonfuse.com

http://www.skylighter.com/mall/books.asp#BK0180

http://www.unitednuclear.com/equipment.htm

BE CAREFUL, HAVE FUN